

Material Models For Thermoplastics In LS-DYNA® From Deformation To Failure

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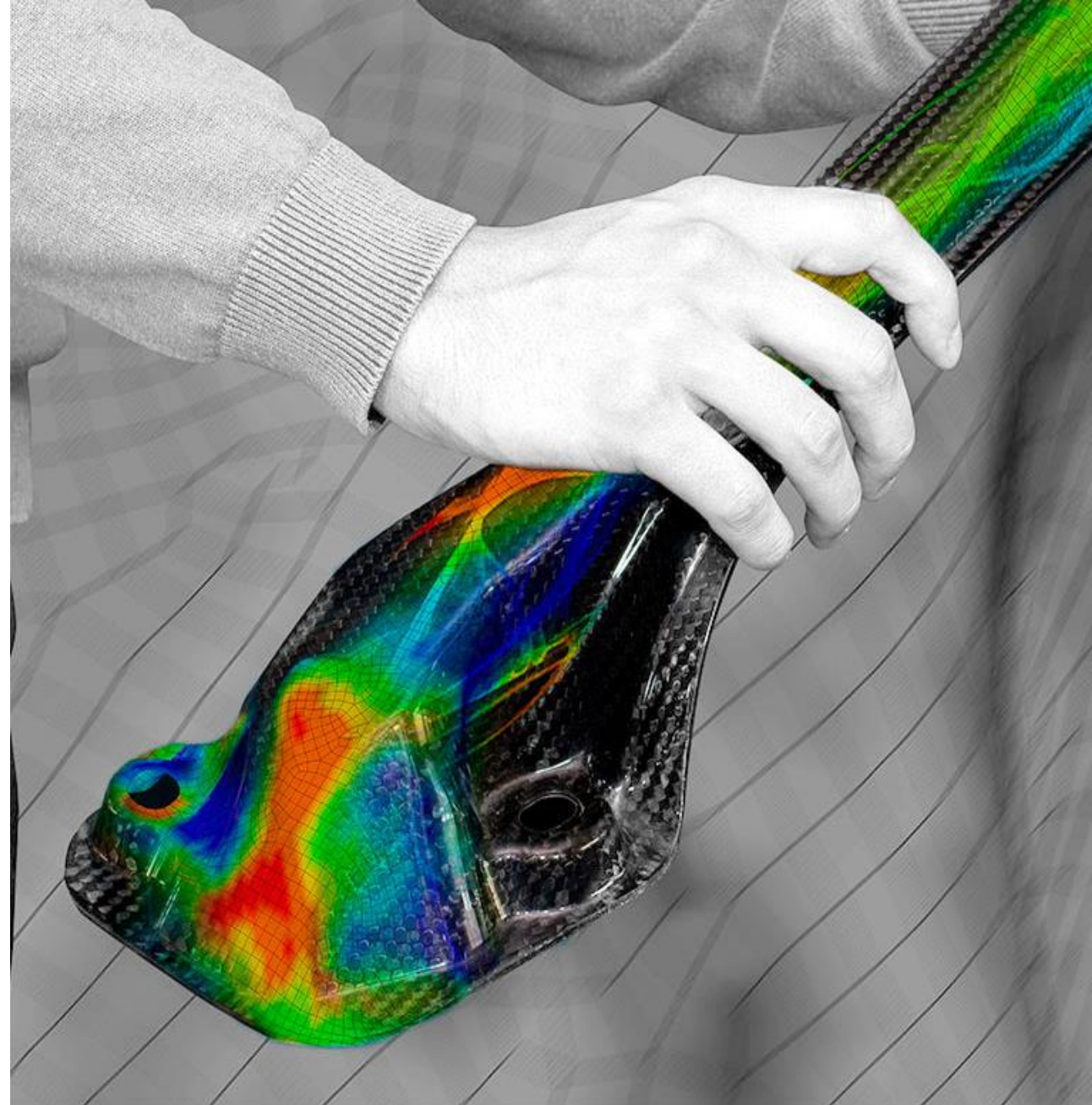
15th International LS-DYNA® Users Conference,
Detroit 12.6.2018

AGENDA

- introduction 4a
- motivation
- material models
- material characterization
- ...
- Summary & Outlook

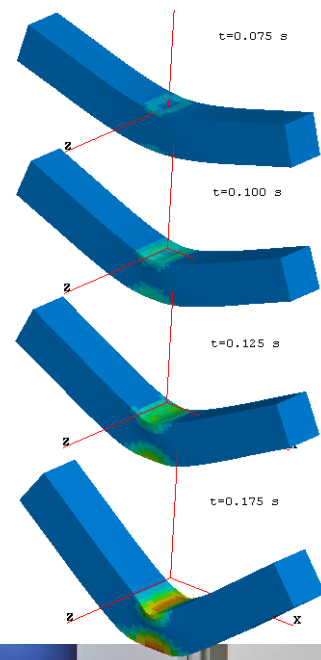
4a engineering

- polymer and materials
- product development
- fiber reinforced plastics and composites
- numerical simulation methods
- method and software development



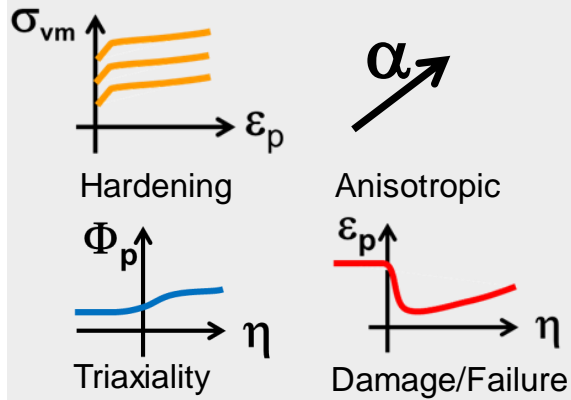
material characterization - services

- efficient high-dynamic testing
- dynamic material behaviour
- plastics, foams, composites, ...
- **validated material cards ready to use for your crash-simulation**



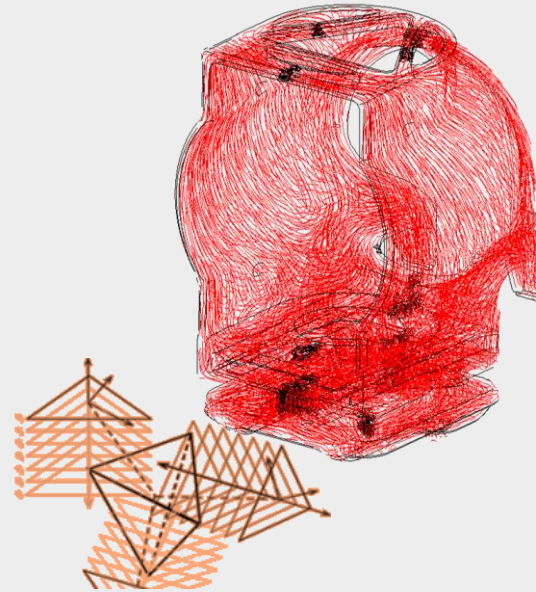
intelligent reliable solutions for plastics, composites, metals, foams, ...

 **VALIMAT**



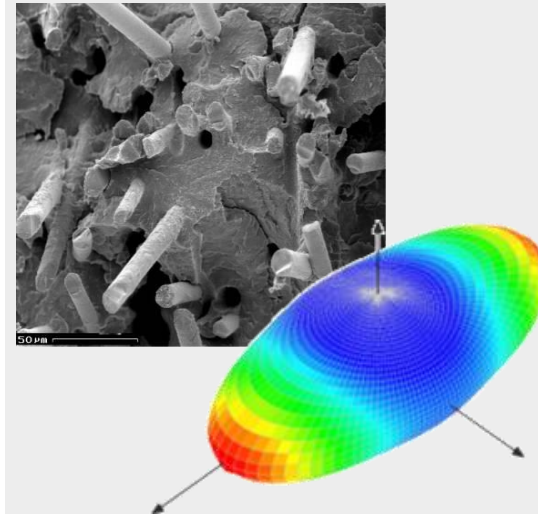
from test to validated material cards

 **FIBERMAP**



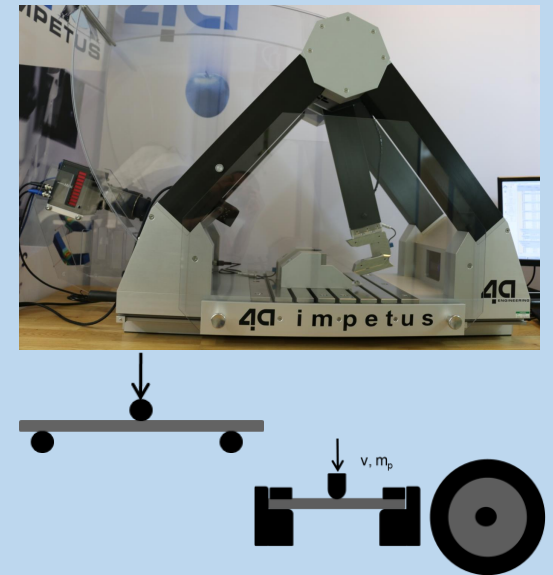
individual mapping process information

 **MICROMECC**



3D anisotropic material cards

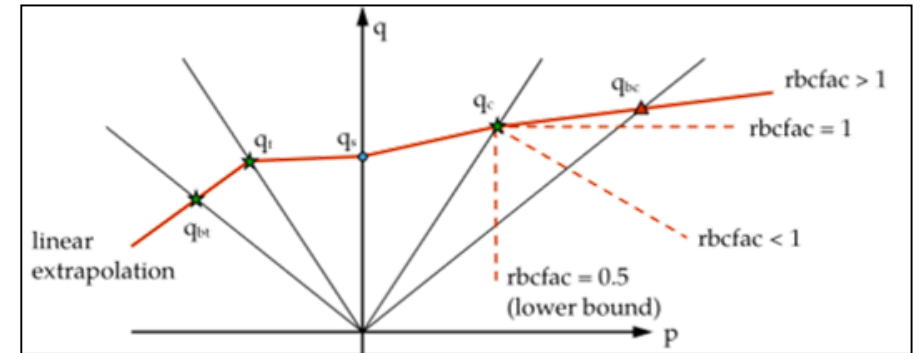
 **IMPETUS**



efficient dynamic testing

Commonly Used Material Models For Plastics

- ***MAT_024 - The workhorse**
(**MAT_081, *MAT_089, *MAT_123, ...*)
- ***MAT_124 - The hidden**
- ***MAT_187 - The plastic expert**



[LSDYNA MANUAL]

Material model	Yield surface	Visco-elasticity	Visco-plasticity	comp./tension symmetry	plastic Poisson's ratio
*MAT_024	von Mises	✘	✓	✘	0.5
*MAT_124	2x von Mises	✓ Pronyseries	✓	✓	0.5
*MAT_187	General over triaxiality	✓ Table	✓	✓	✓

Characterizing mechanical deformation behavior of plastics

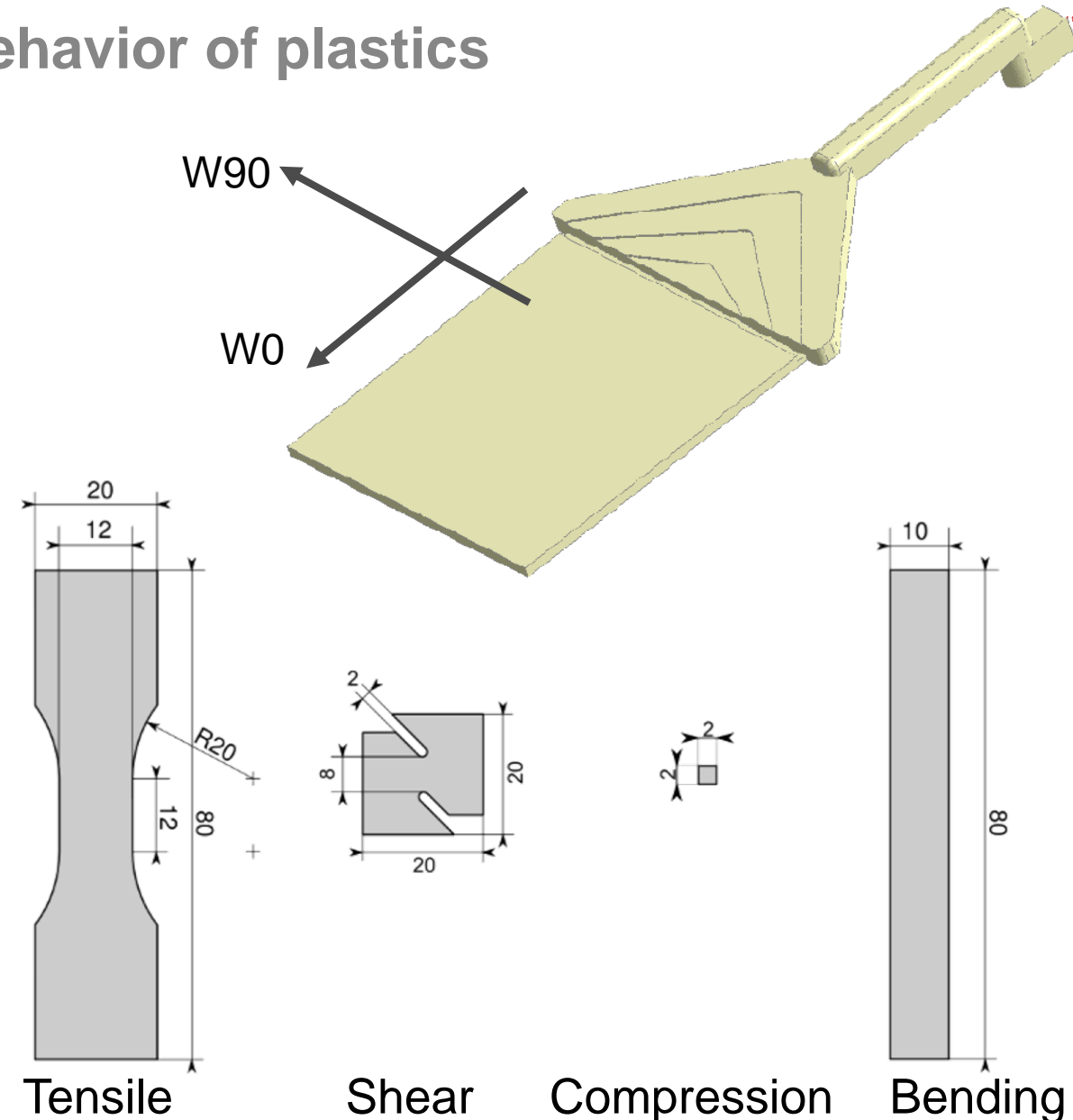
Ph.D-thesis of F. Kunkel

- Injection molded PP T16 (Hostacom XBR 169G)
- specimen milled out in W0 and W90
- classical static and dynamic tests with **DIC**

The Old School - material characterization as described in the material model

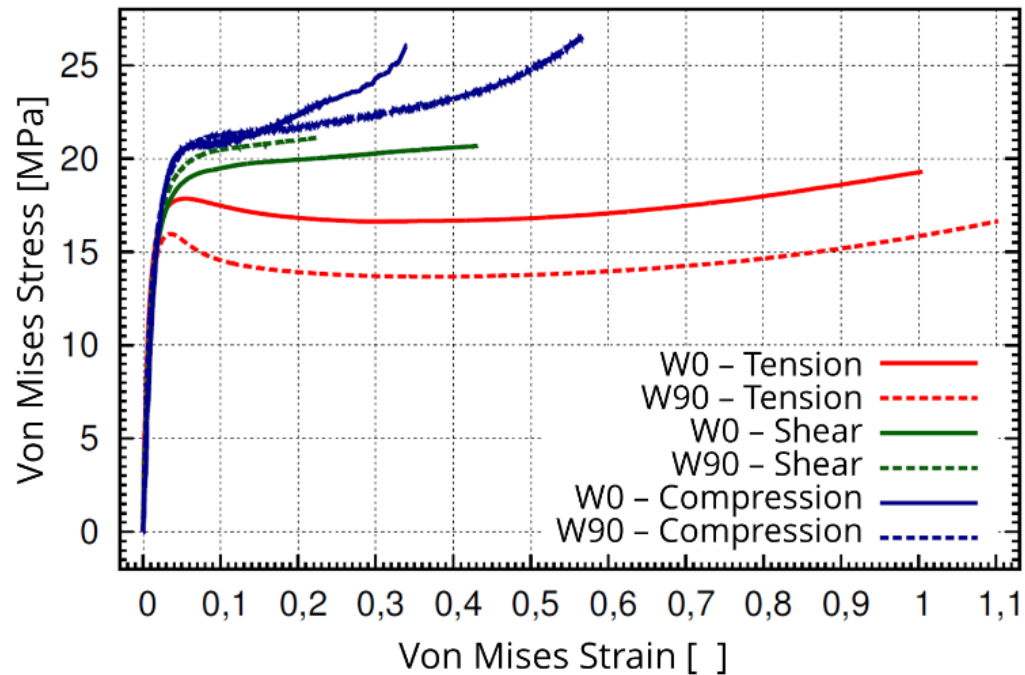
- Tensile
- Shear
- Compression

comparison IMPETUS™ bending

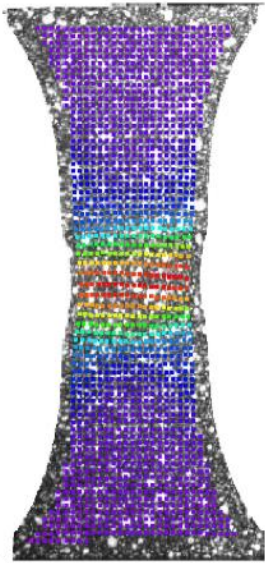
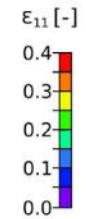
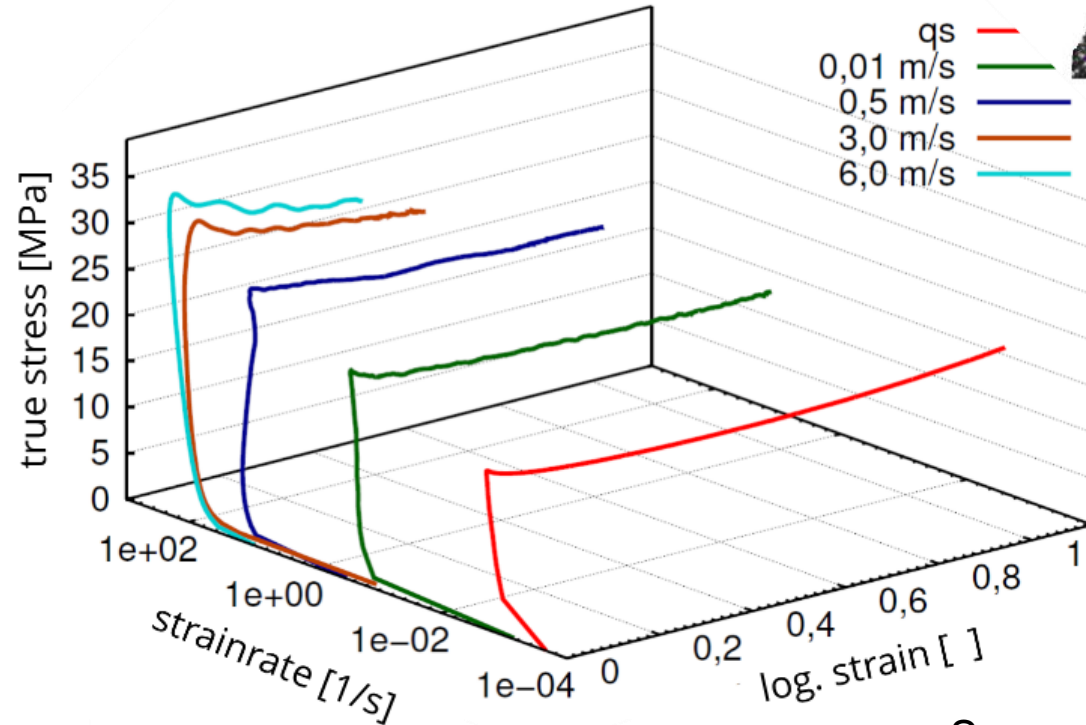


Characterizing mechanical deformation behavior of plastics

The Old School - material characterization as described in the material model



→ no constant loading (triaxiality) and strain rate

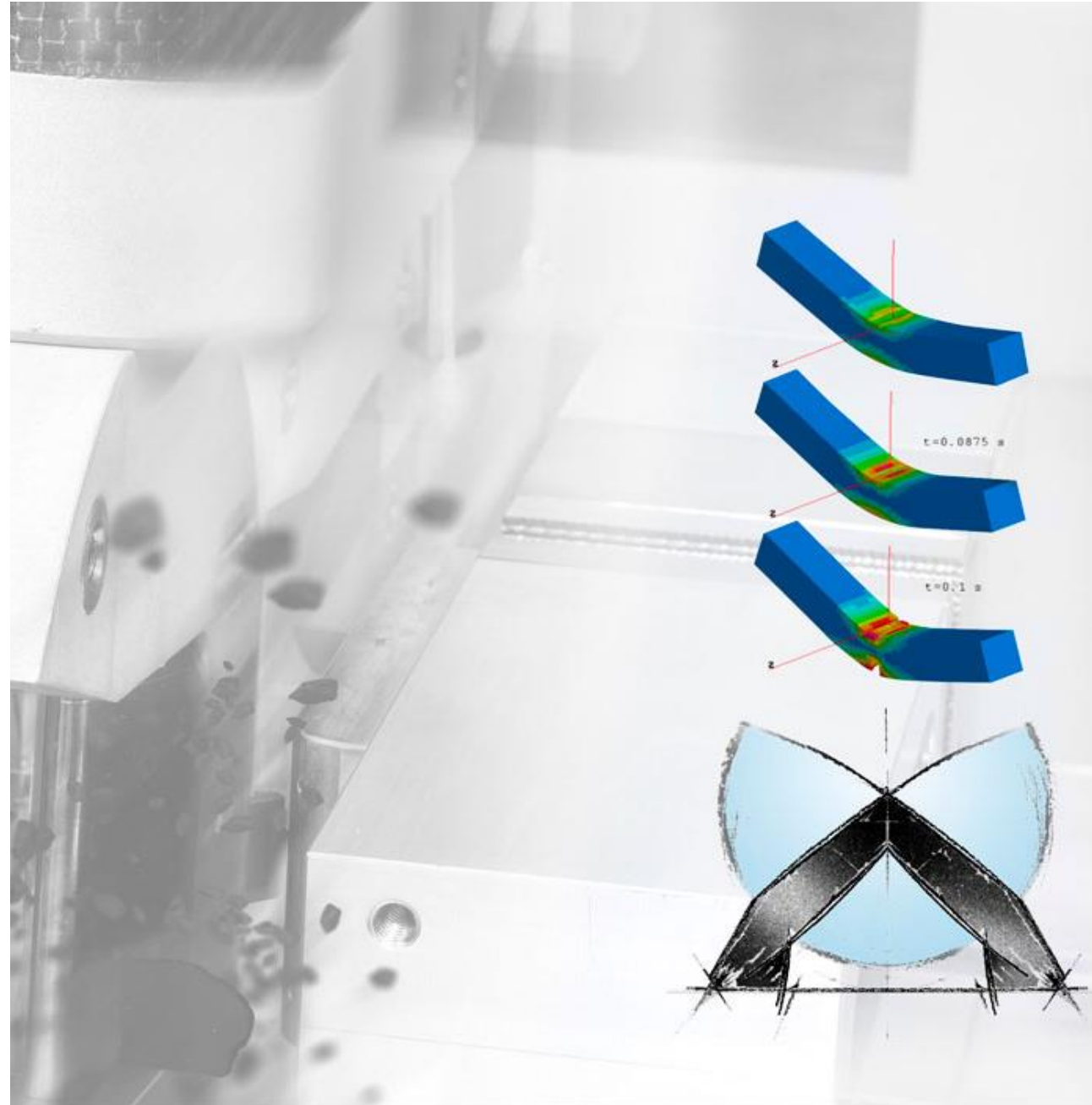


Source: F. Kunkel

efficient dynamic testing

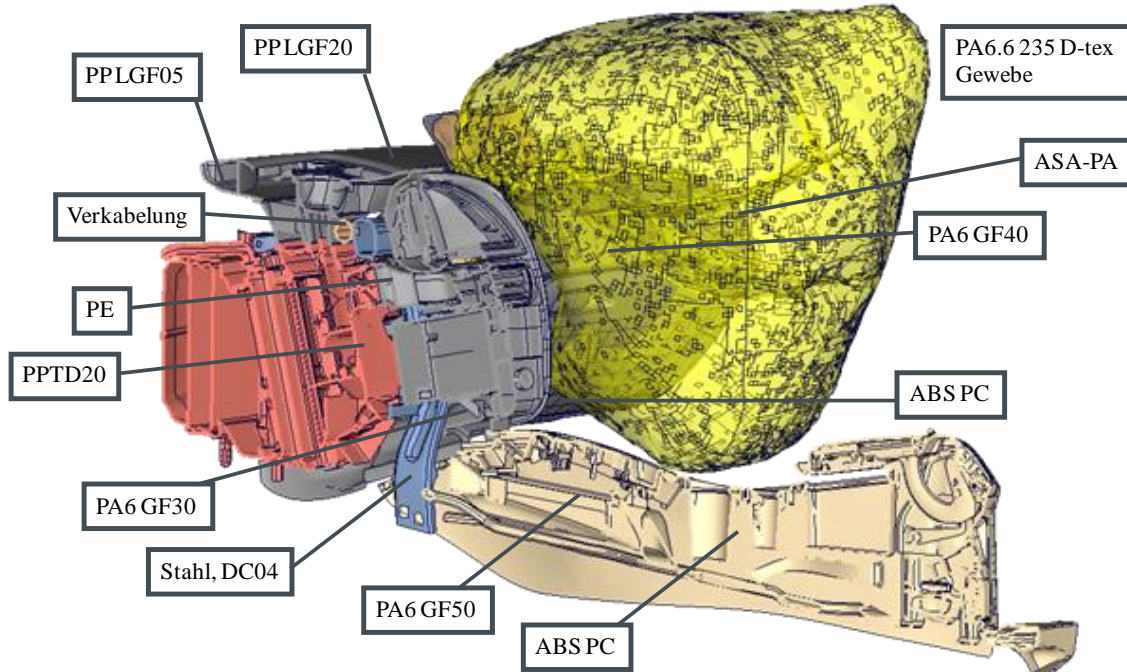


engineering plastics production
concepts excellence in testing simulation
lightweight prototypes



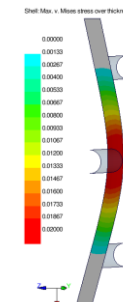
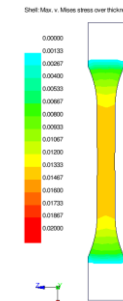
2004 - motivation

material variety

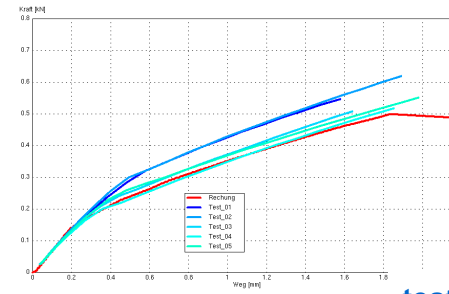


Source: R. Luijckx - *Kunststoffmaterialien in der Interieur Funktionsauslegung bei Audi AG*, 4a Technologietag 2010

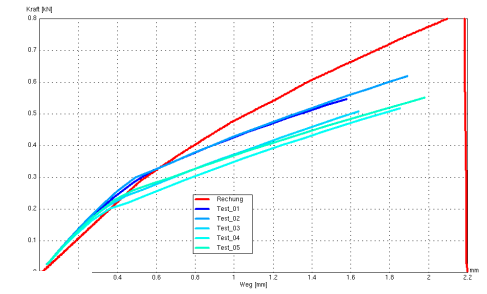
bending load case



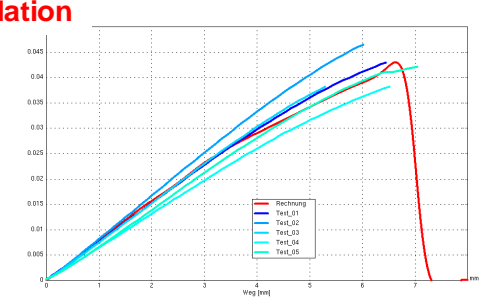
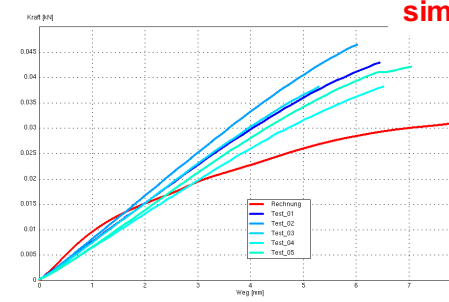
original test curve tension



scaling 1.25

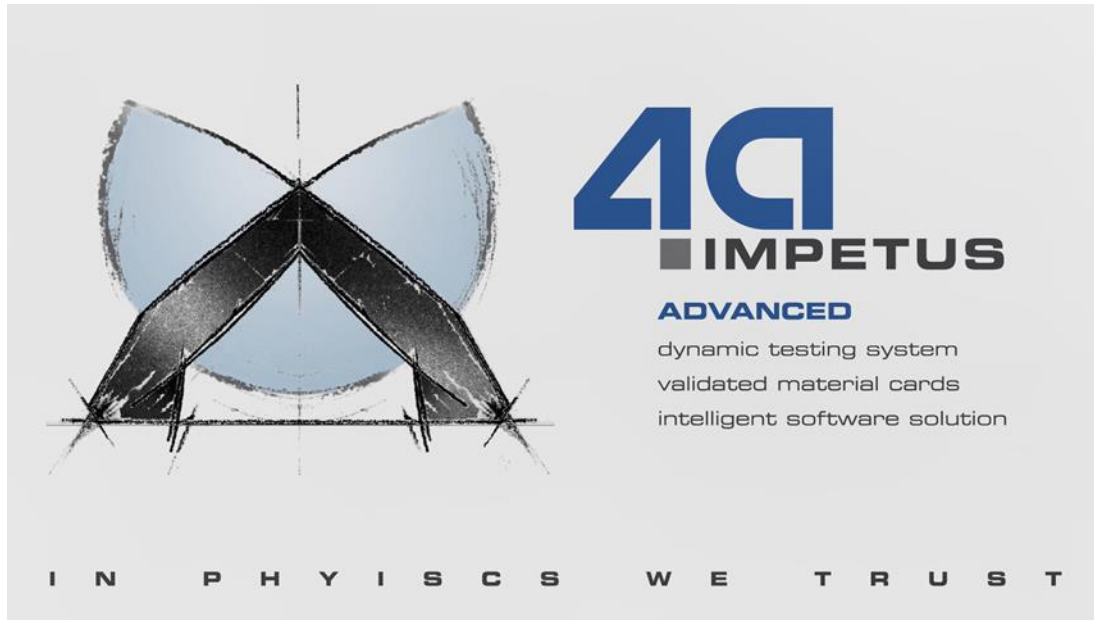
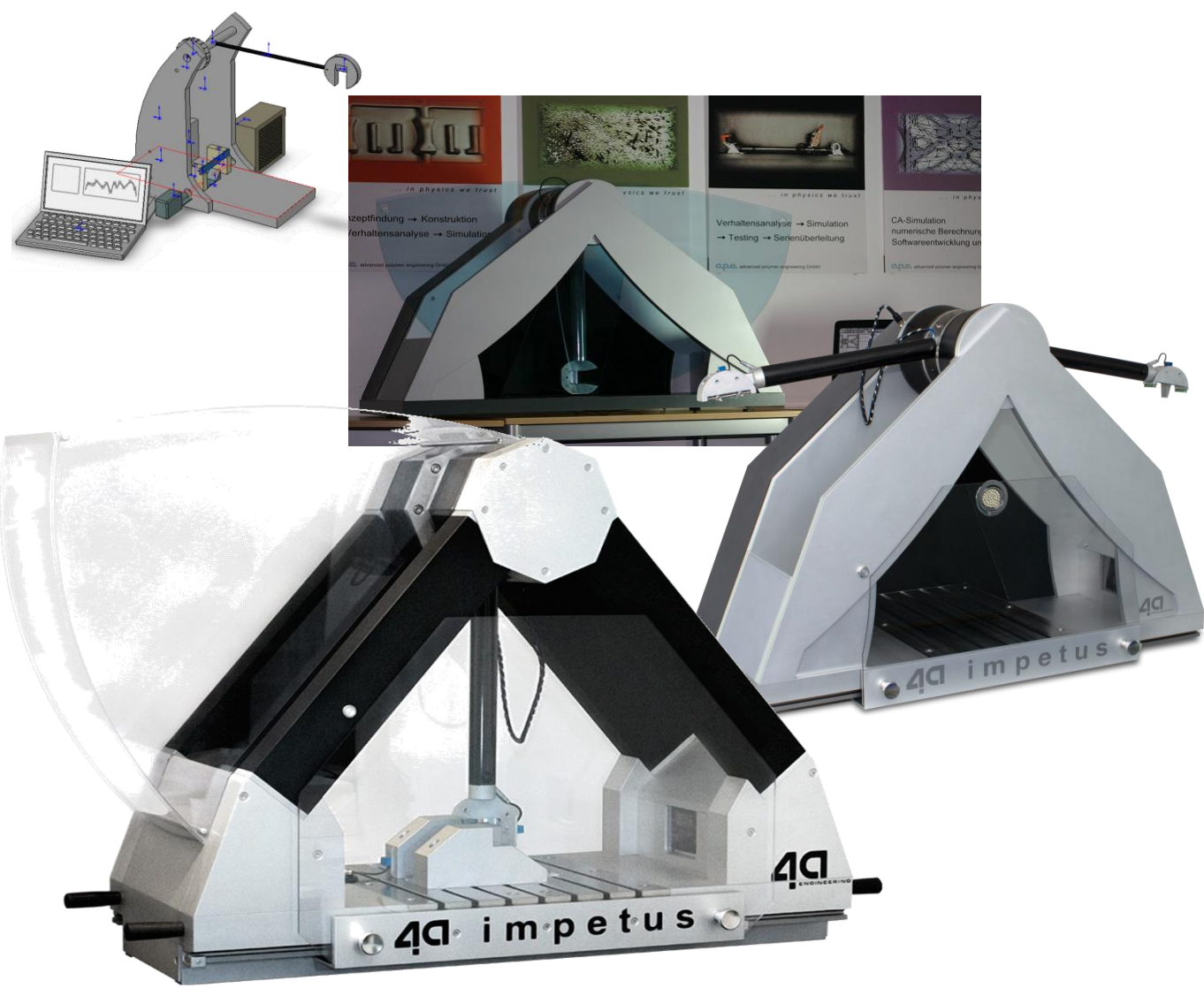


test
simulation



efficient dynamic testing

- desktop testing device
- instrumented high speed testing
 - acceleration → force / displacement
- impact velocity 0.5 – 4.5 m/s
- maximum energy 50 J

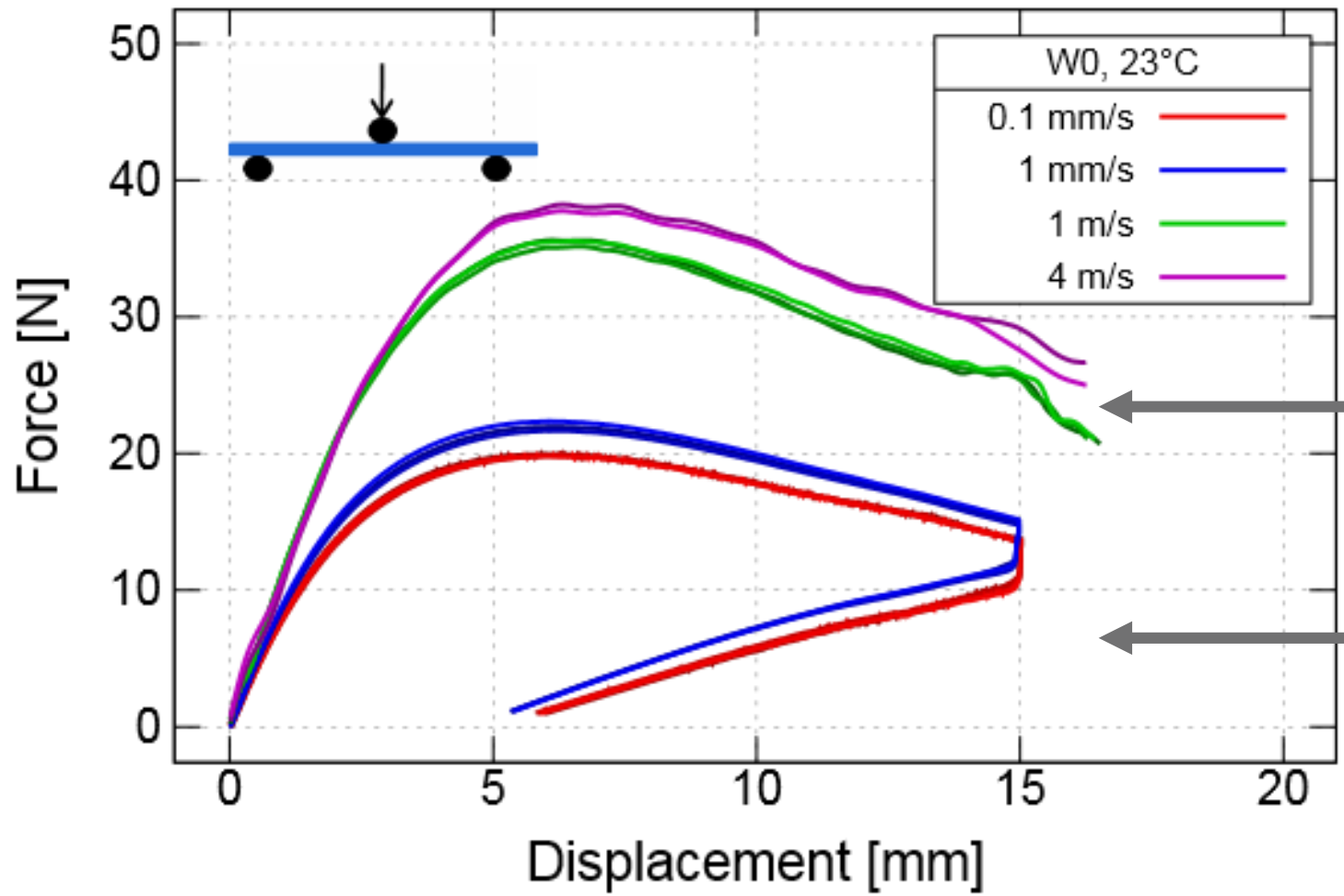


4Q
IMPETUS
ADVANCED
dynamic testing system
validated material cards
intelligent software solution

I N P H Y S I C S W E T R U S T

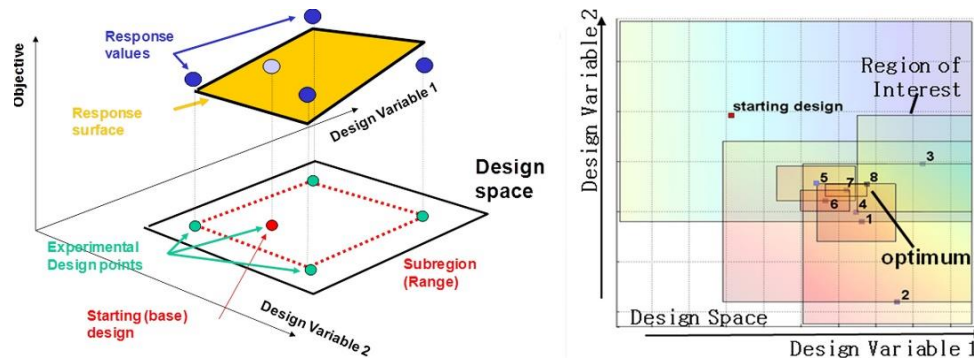
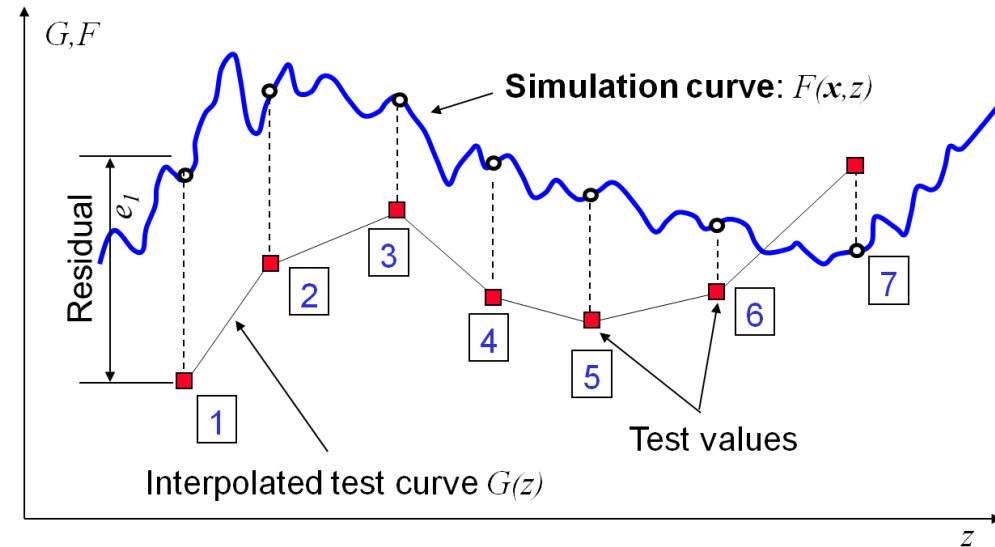
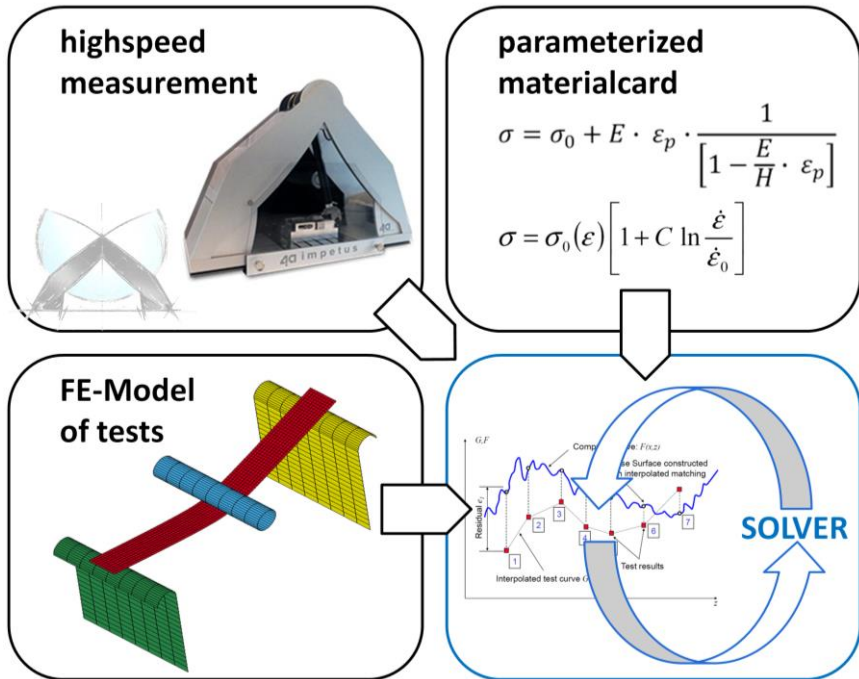


efficient dynamic testing



Universal static testing

reverse engineering

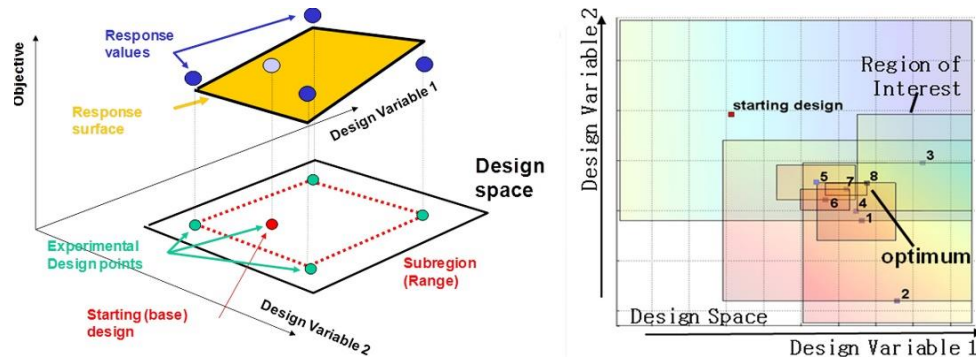
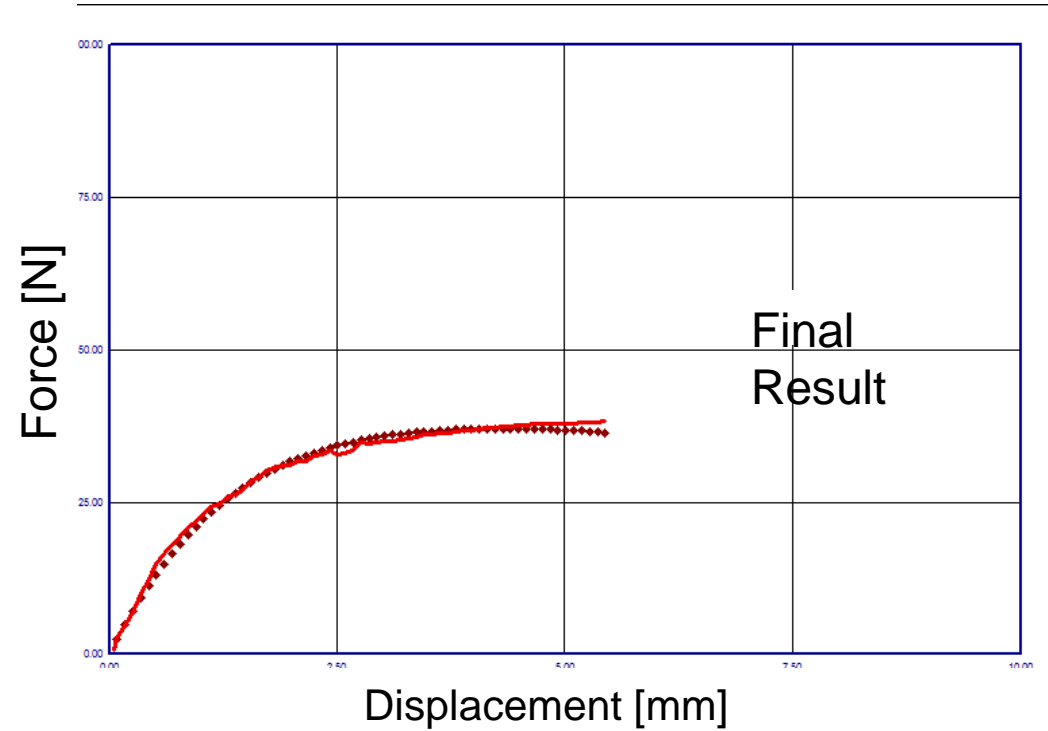
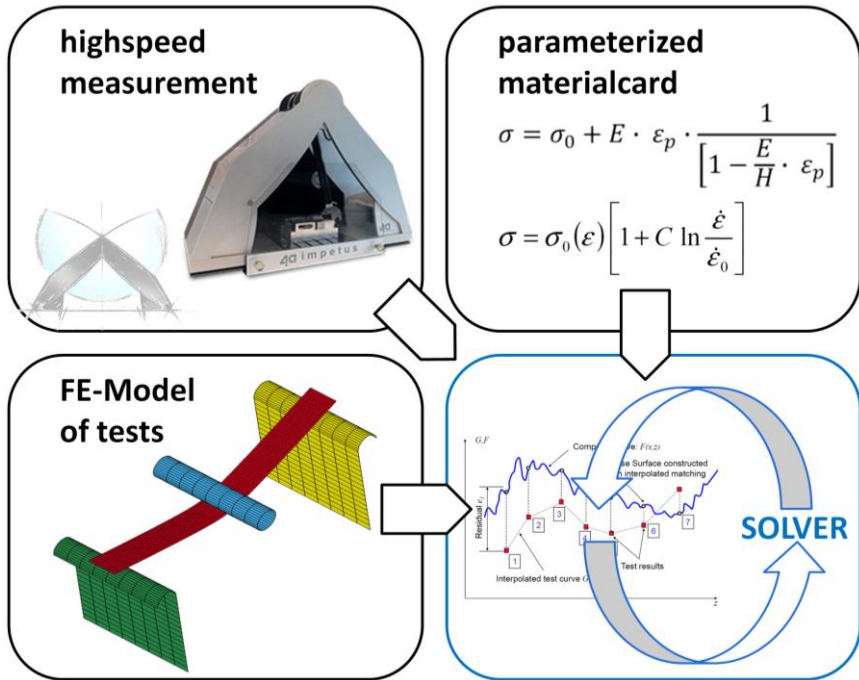


Mean Squared Error

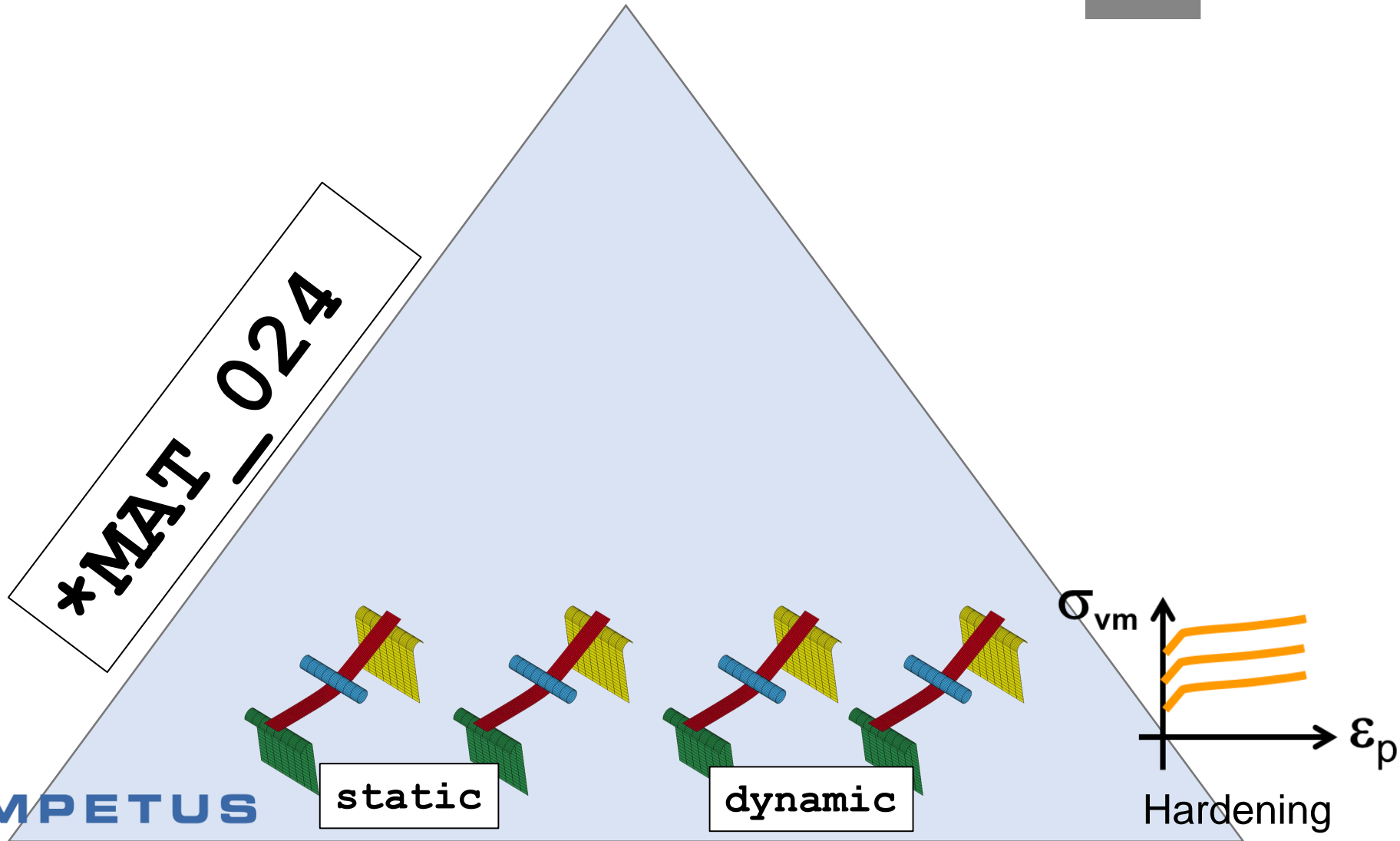
$$MSE(\mathbf{x}) = \frac{1}{P} \sum_{i=1}^P W_i \left(\frac{F_i(\mathbf{x}) - G_i}{s_i} \right)^2 \rightarrow \min$$

Source: Dynamic Material Characterization Using 4a impetus – PPS Conference 2015, Graz

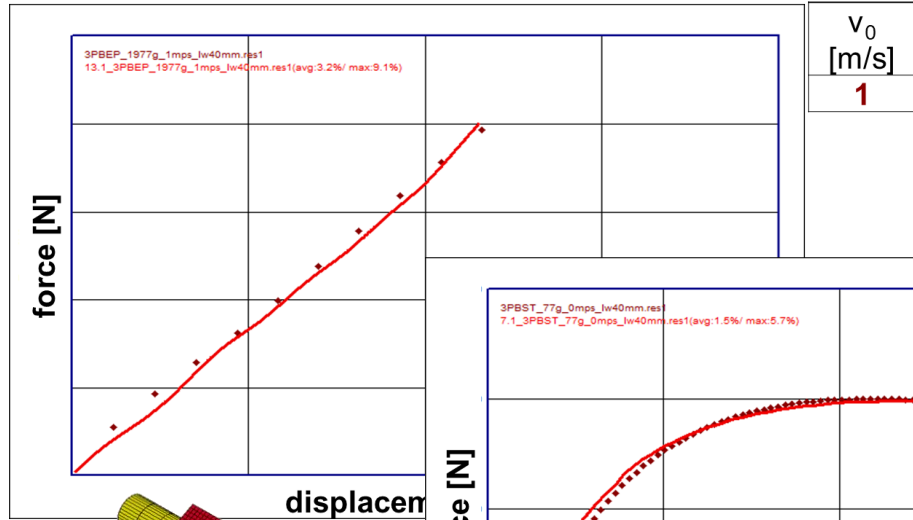
reverse engineering



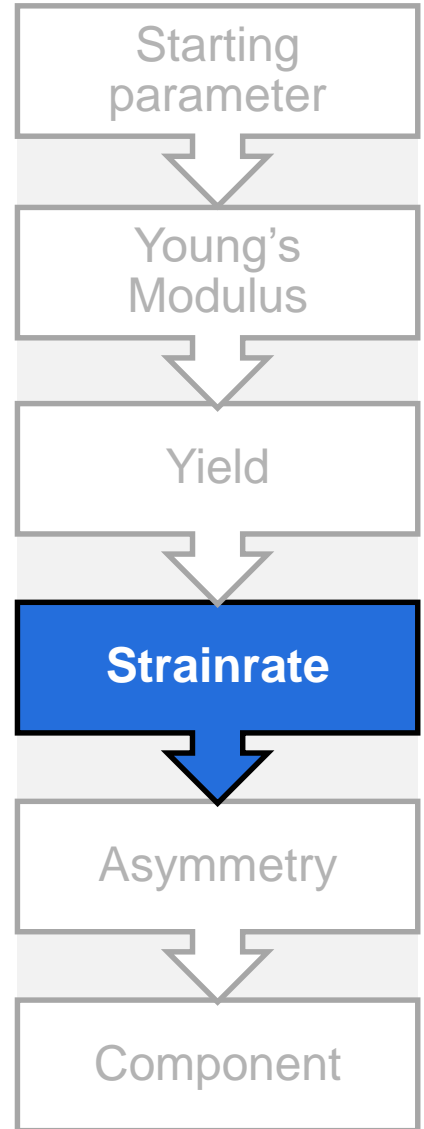
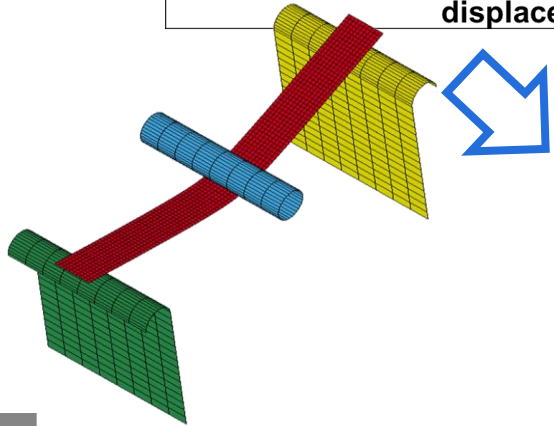
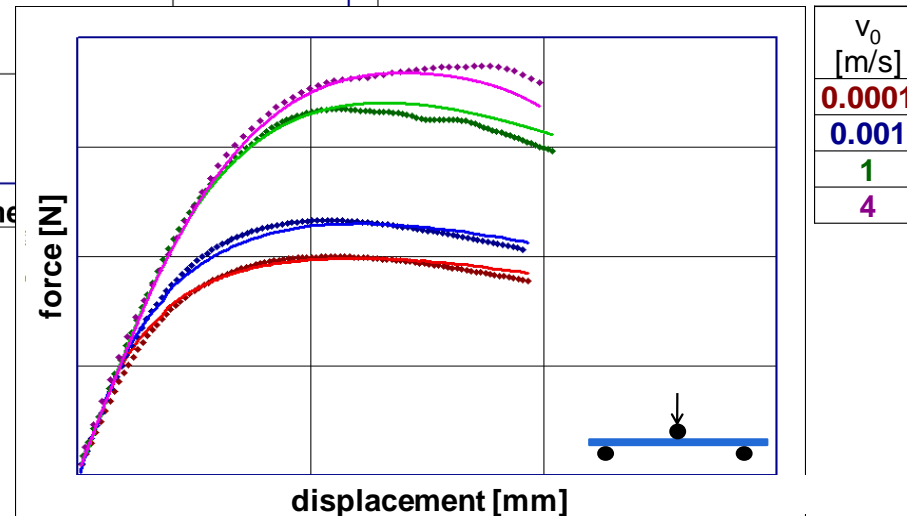
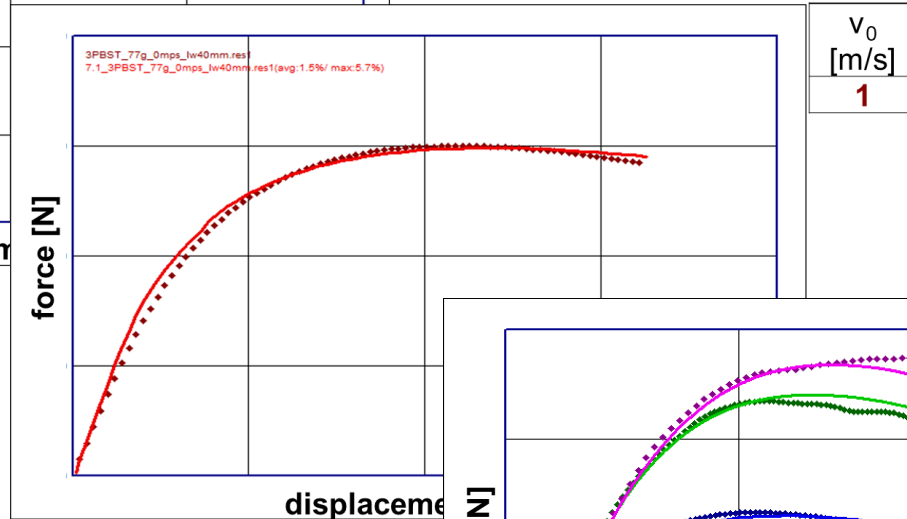
Source: Dynamic Material Characterization Using 4a impetus – PPS Conference 2015, Graz



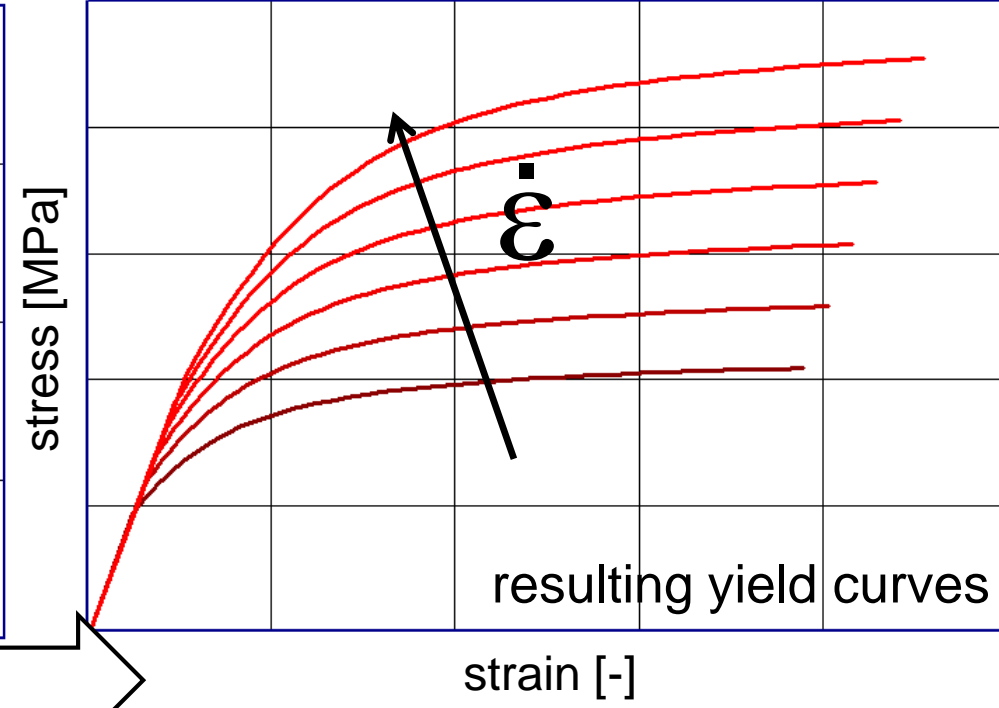
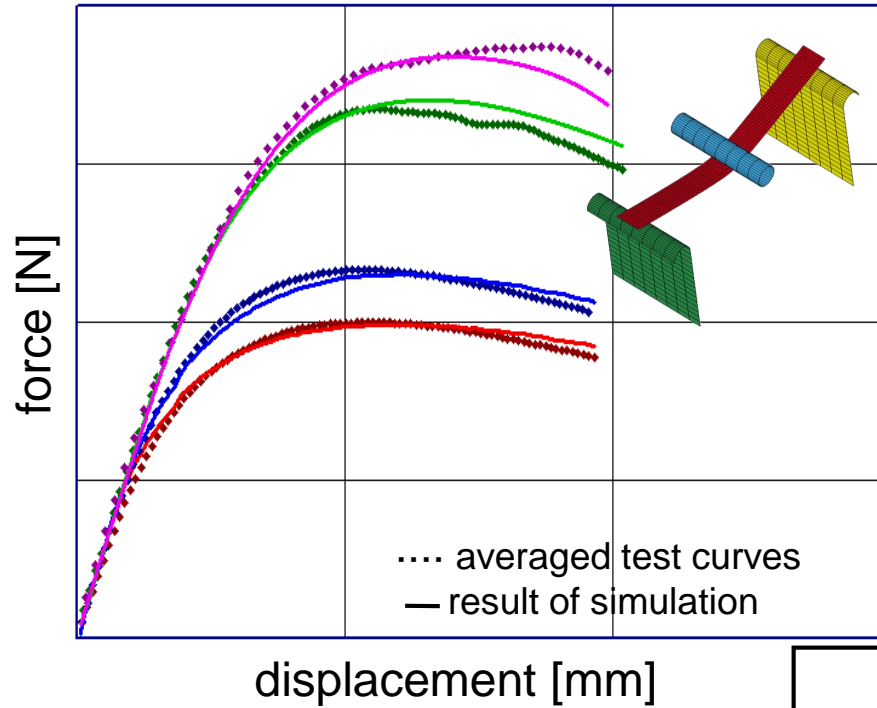
from bending → *MAT_024



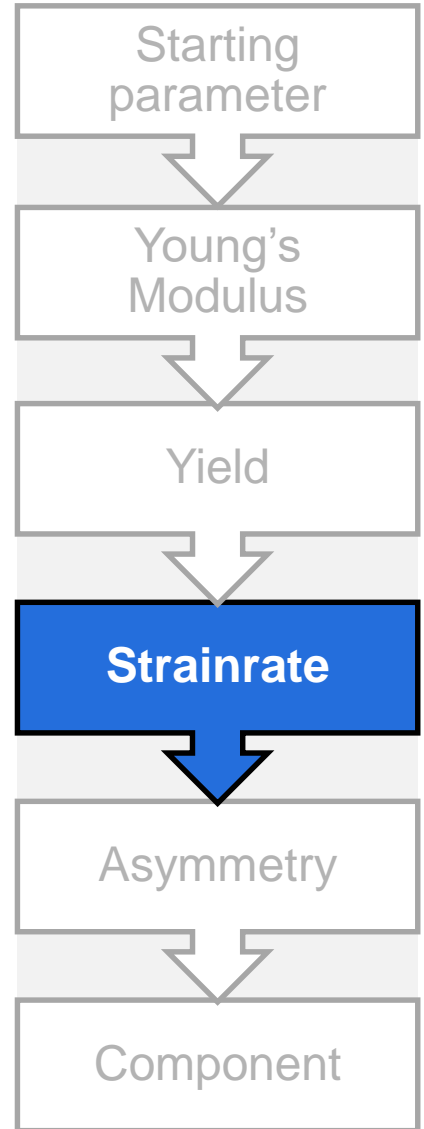
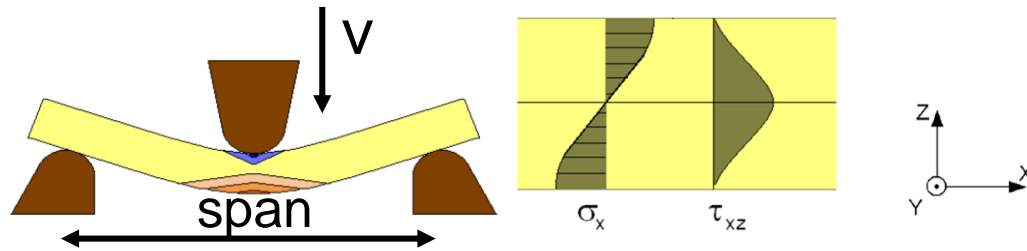
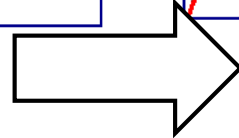
..... averaged test curves
— result of simulation

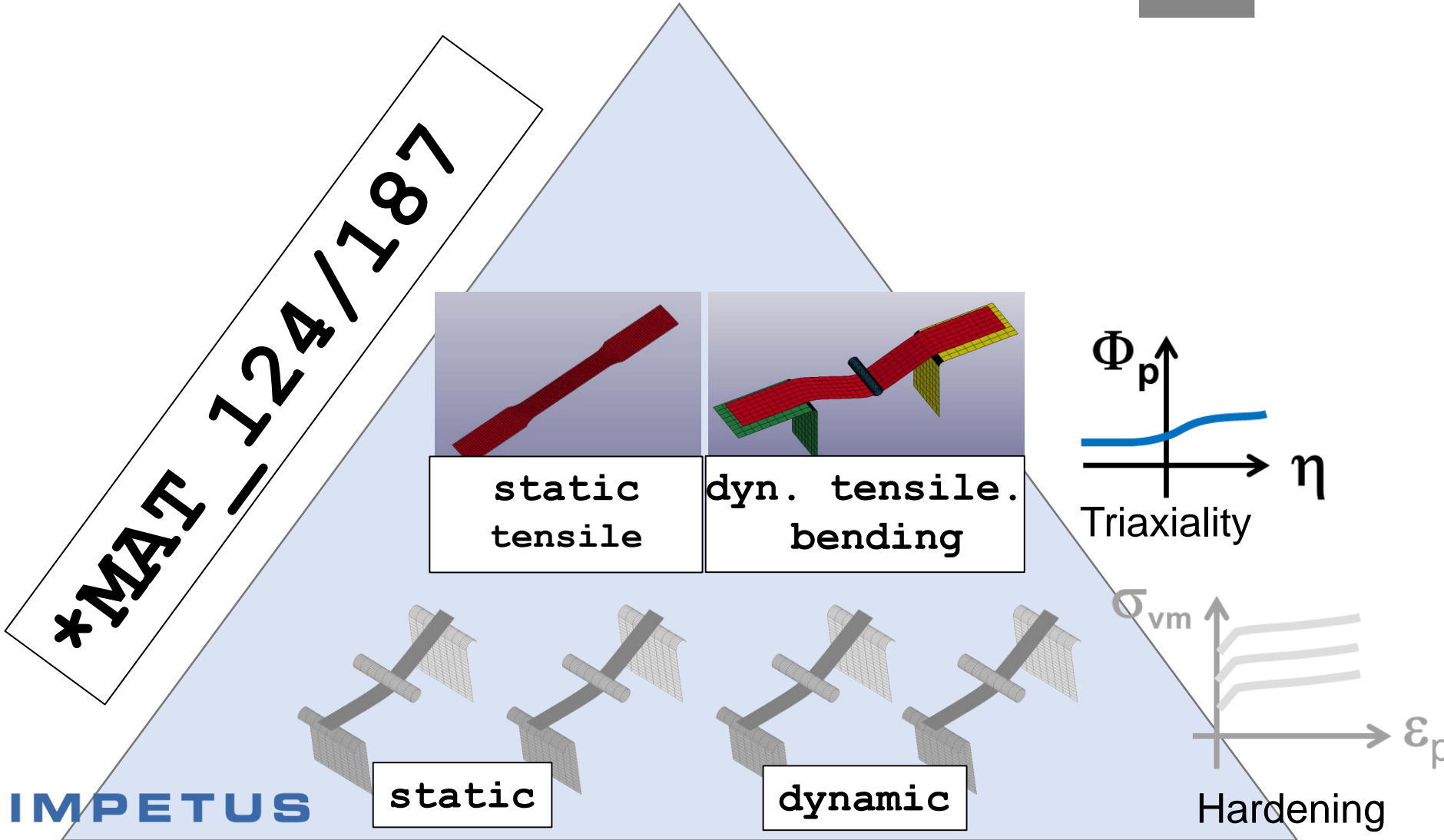


from bending → *MAT_024

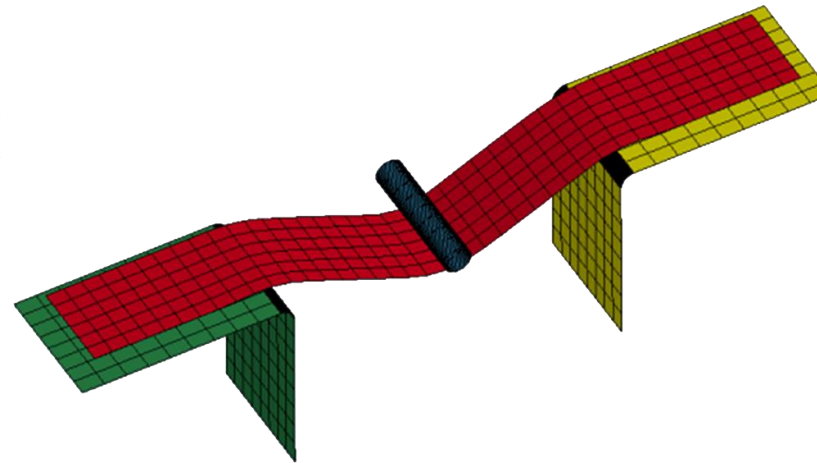
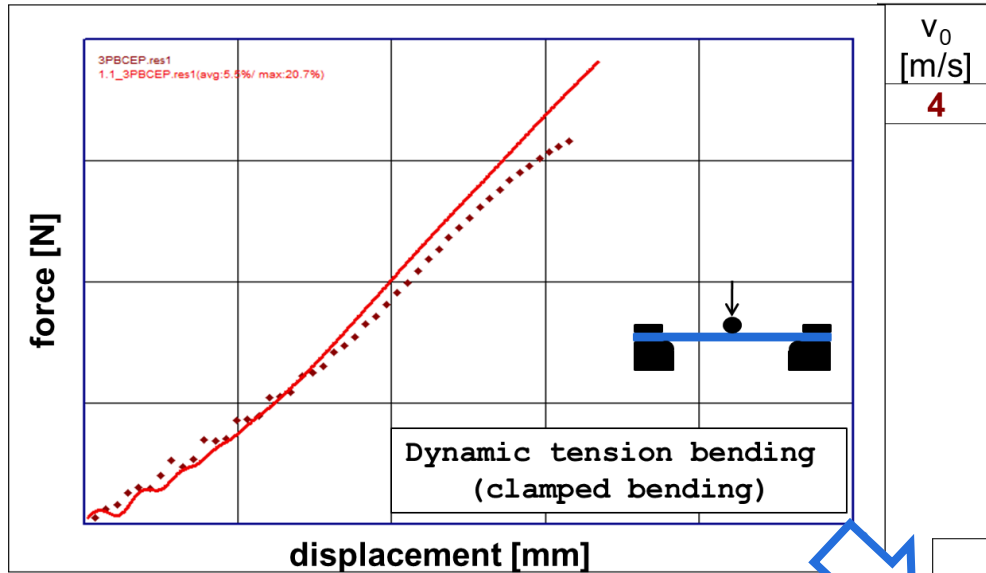


v [m/s]	span [mm]
0.0001	40
0.001	40
1	40
4	40

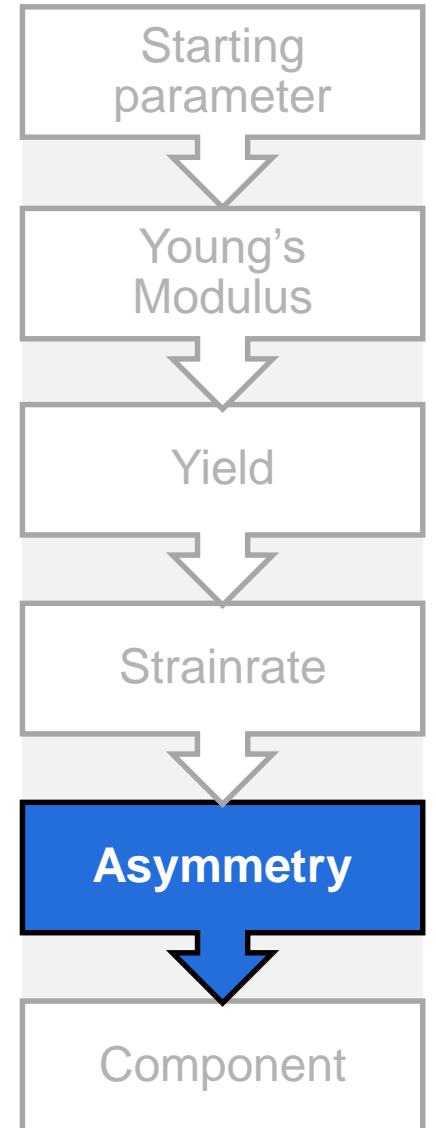
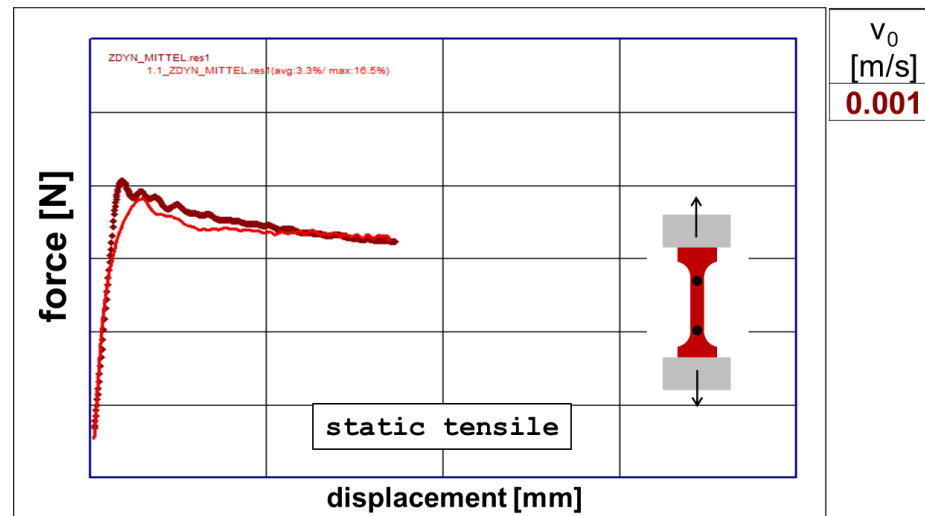




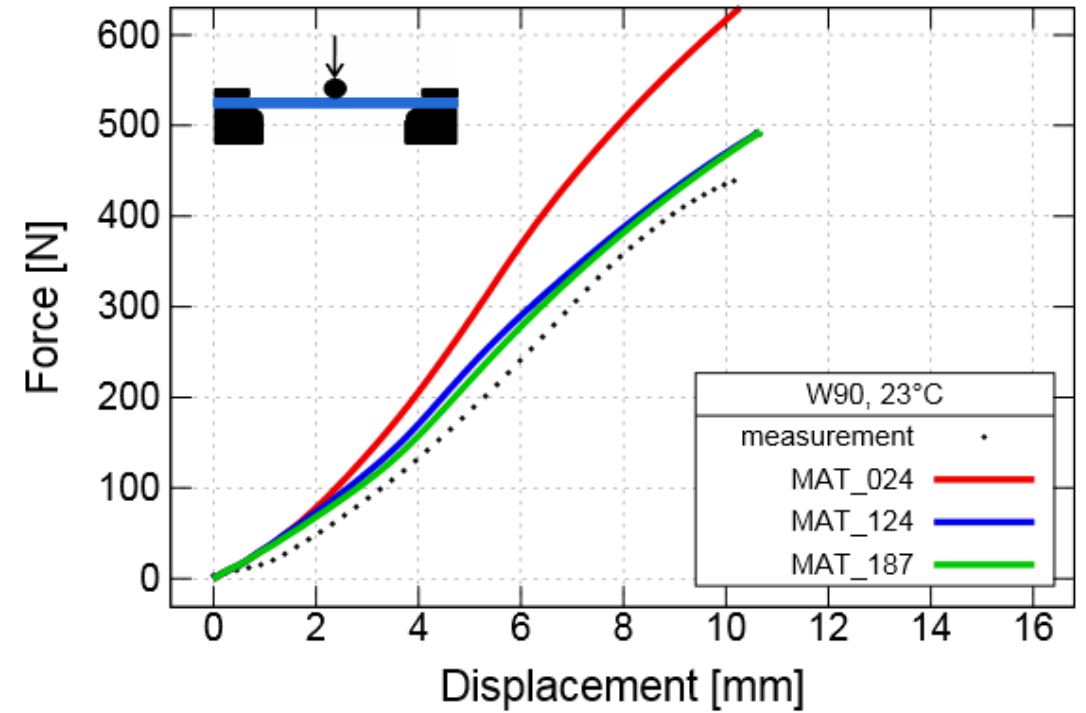
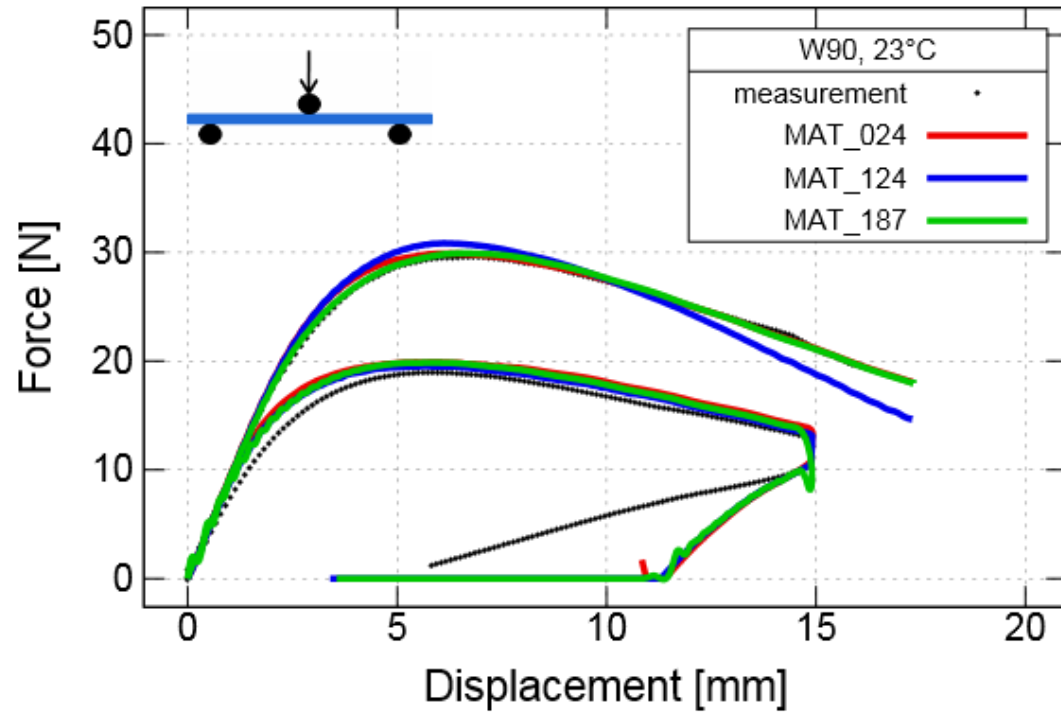
from tension bending → *MAT_124/187



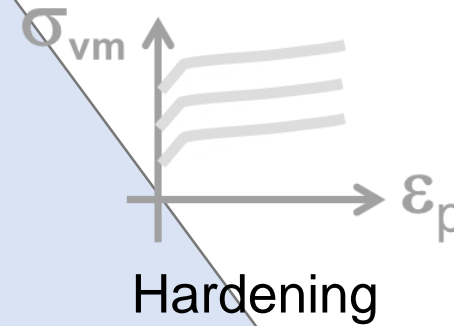
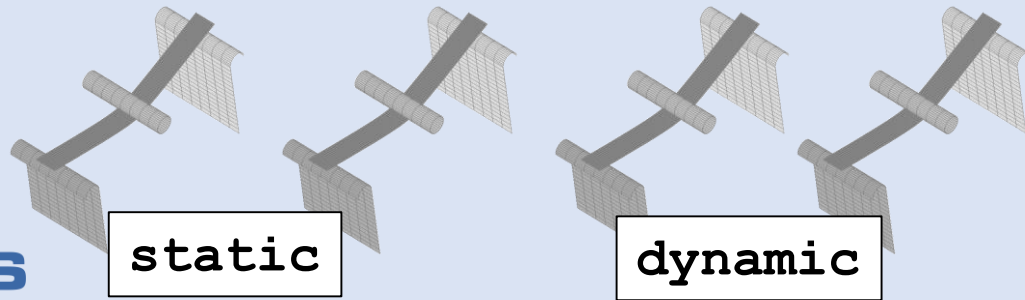
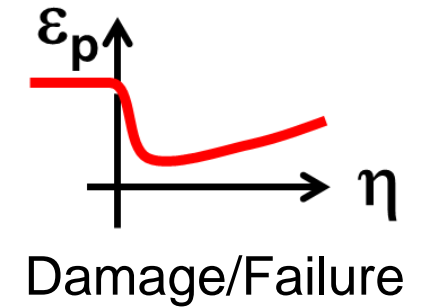
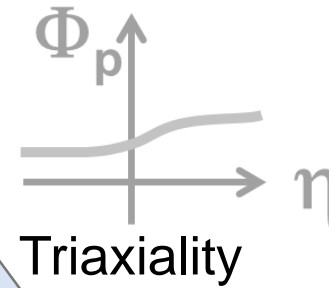
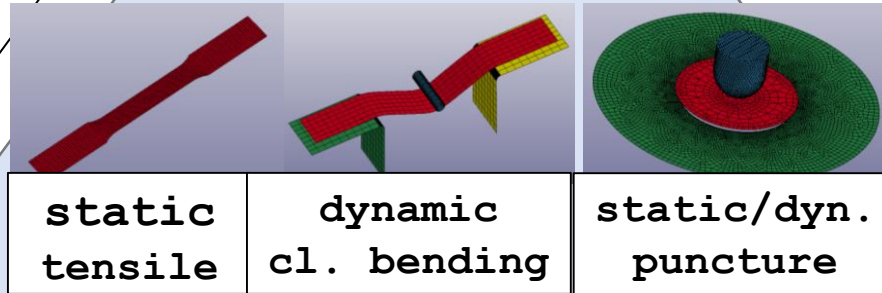
.... averaged test curves
 — result of simulation



MPIP - comparison of results

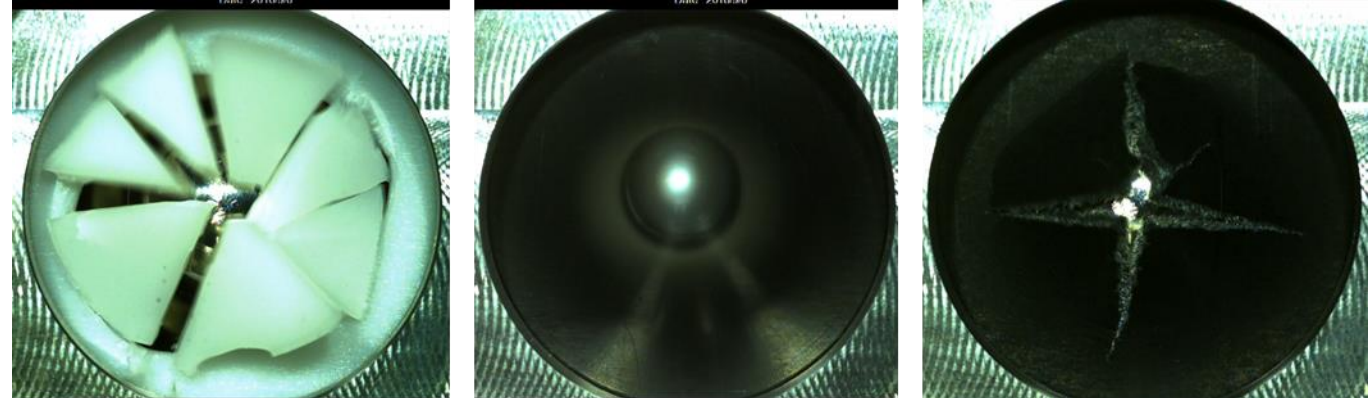
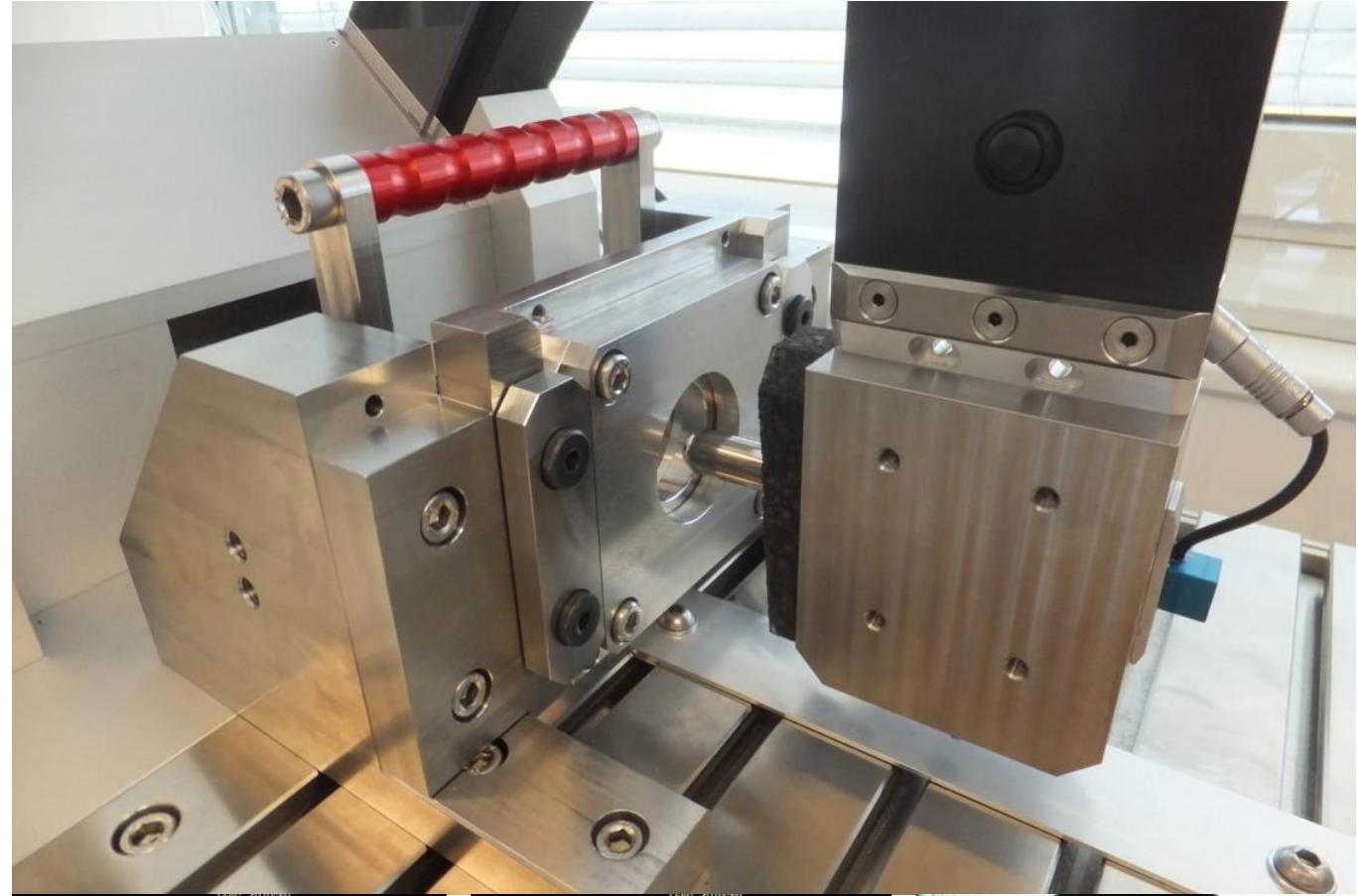


***MAT_ADD_ERROSION**



efficient dynamic testing

- Different load cases
 - Bending
 - Tension Bending
 - Compression
 - Puncture
 - Component
 - ...
- High speed camera
 - Sync. recording
- Maximum energy 50 J
- Material Card
Deformation → Failure



injection mold for material characterization

DOM & Wall thickness



Melt- & Weldlines

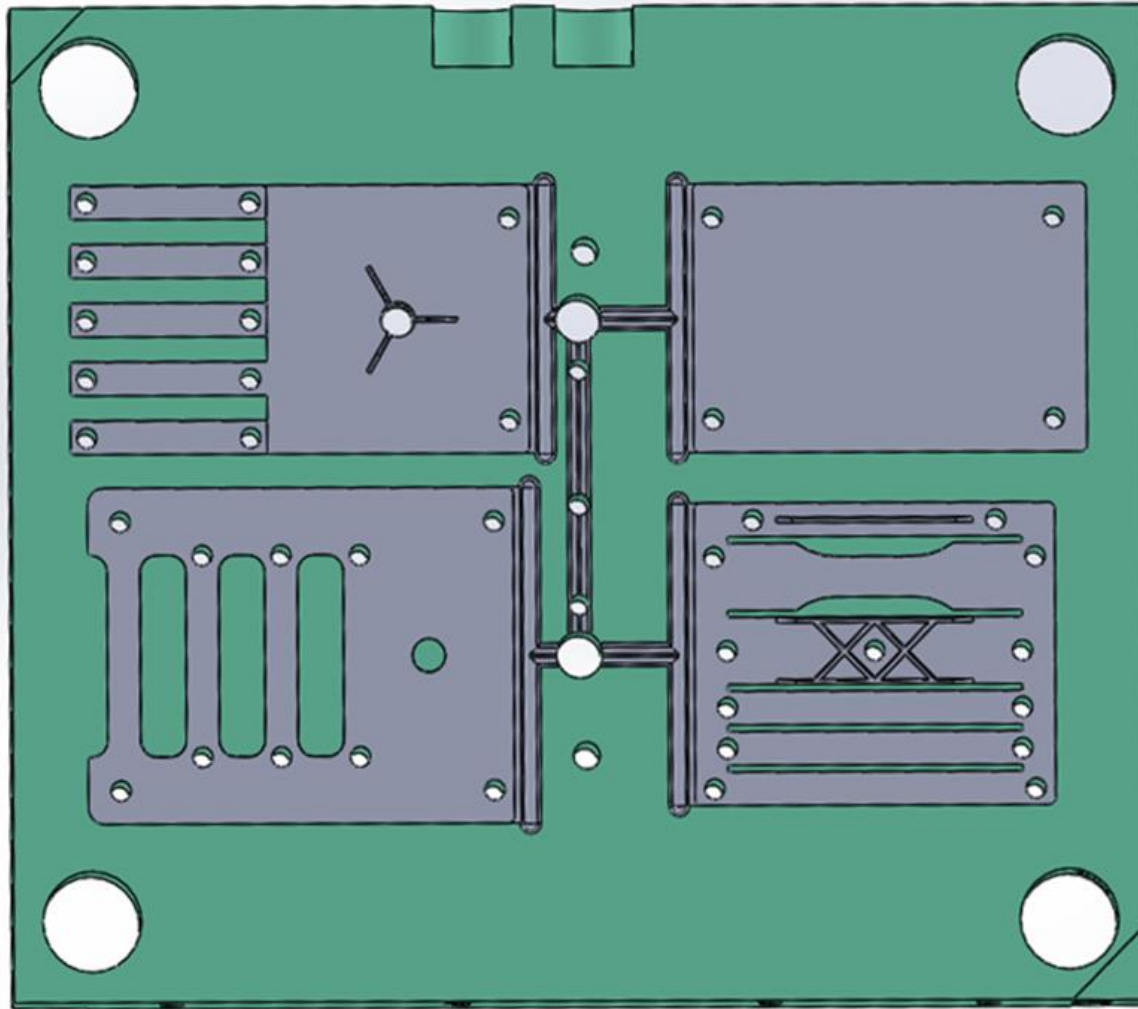
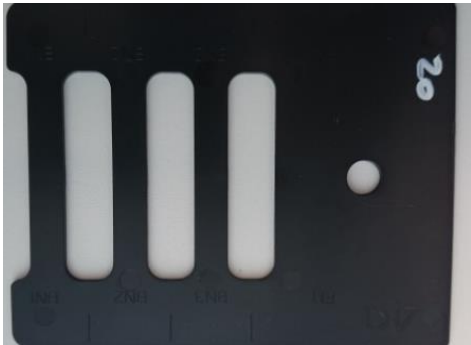


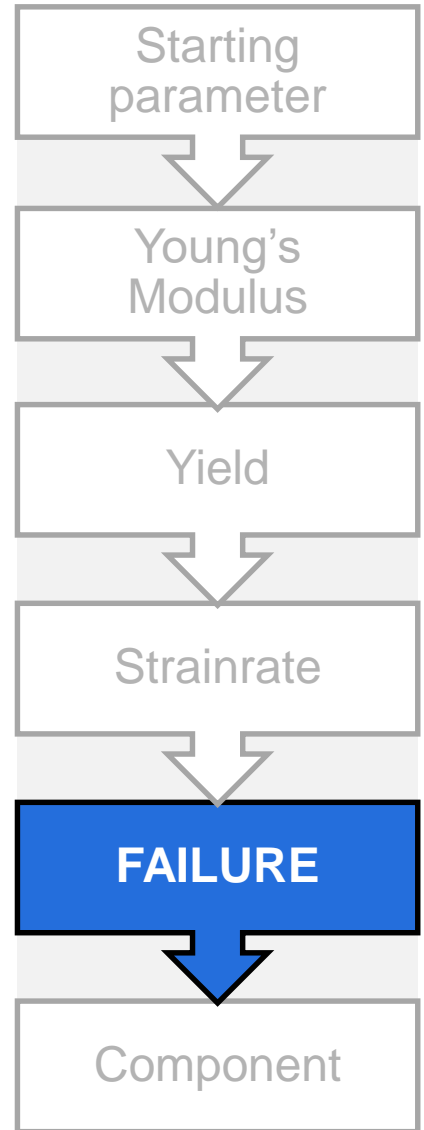
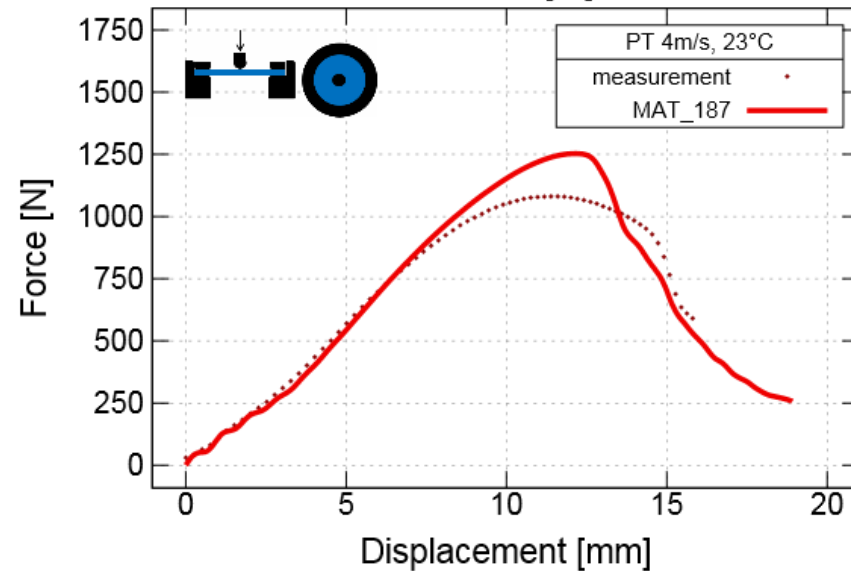
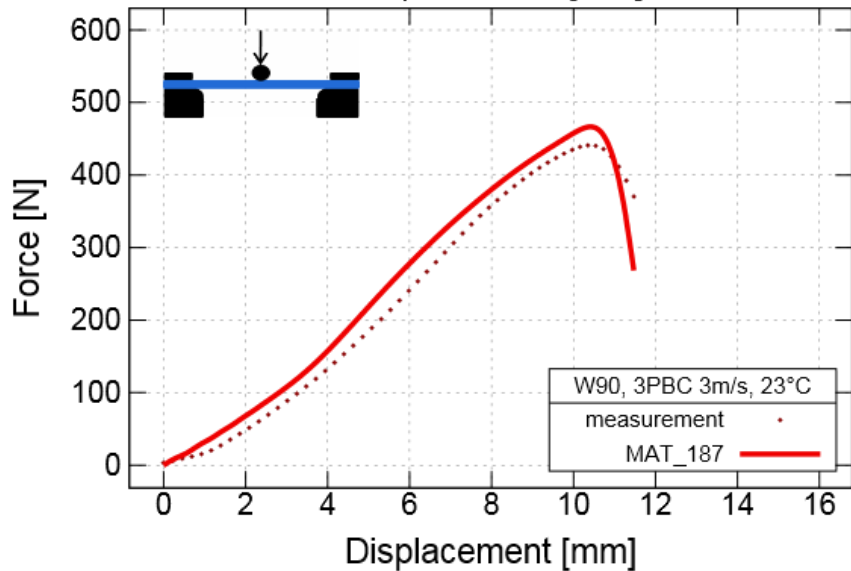
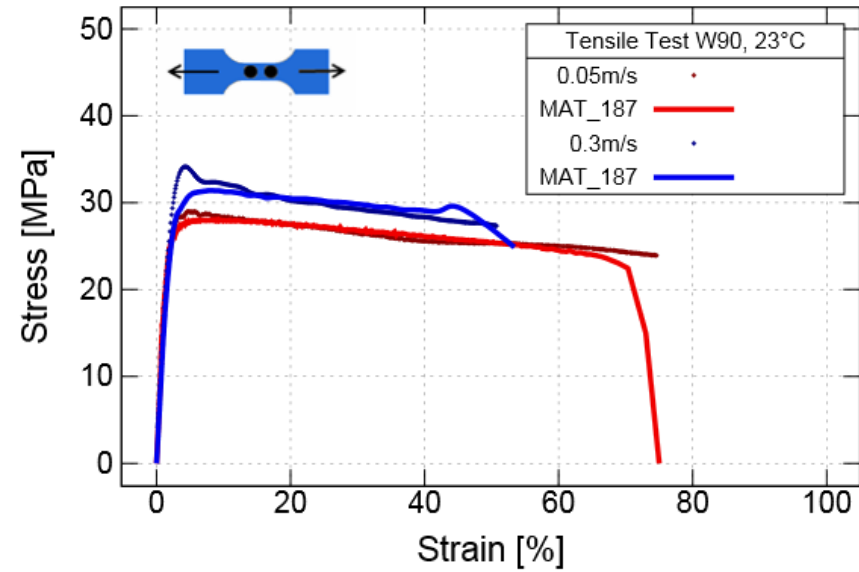
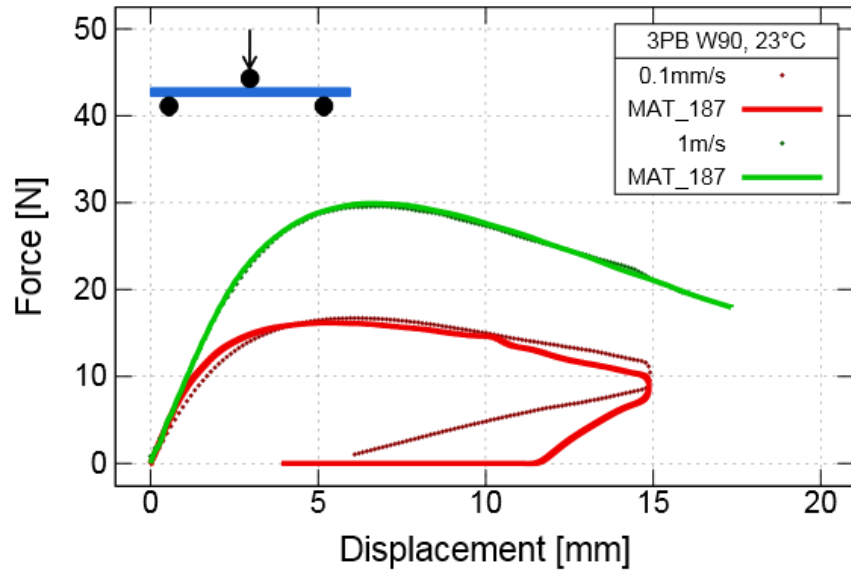
Plate 120 x 80 x 2 mm



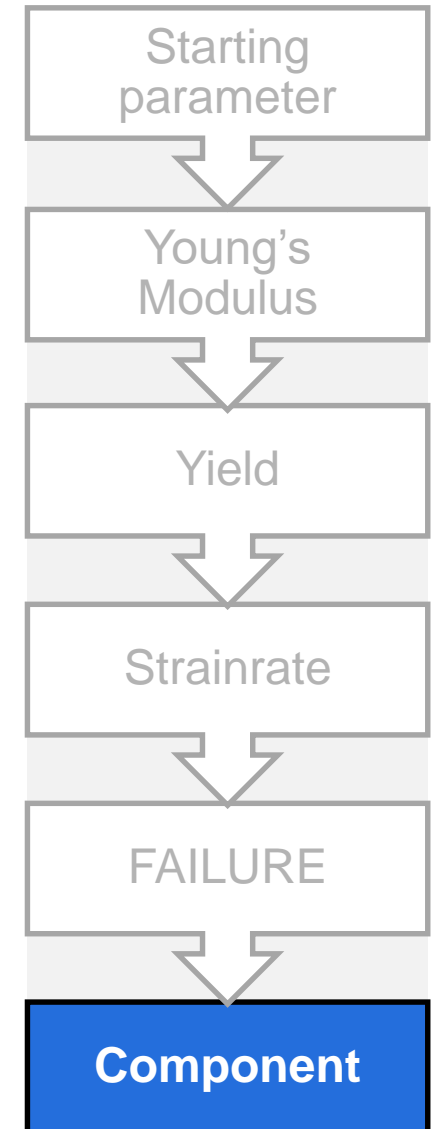
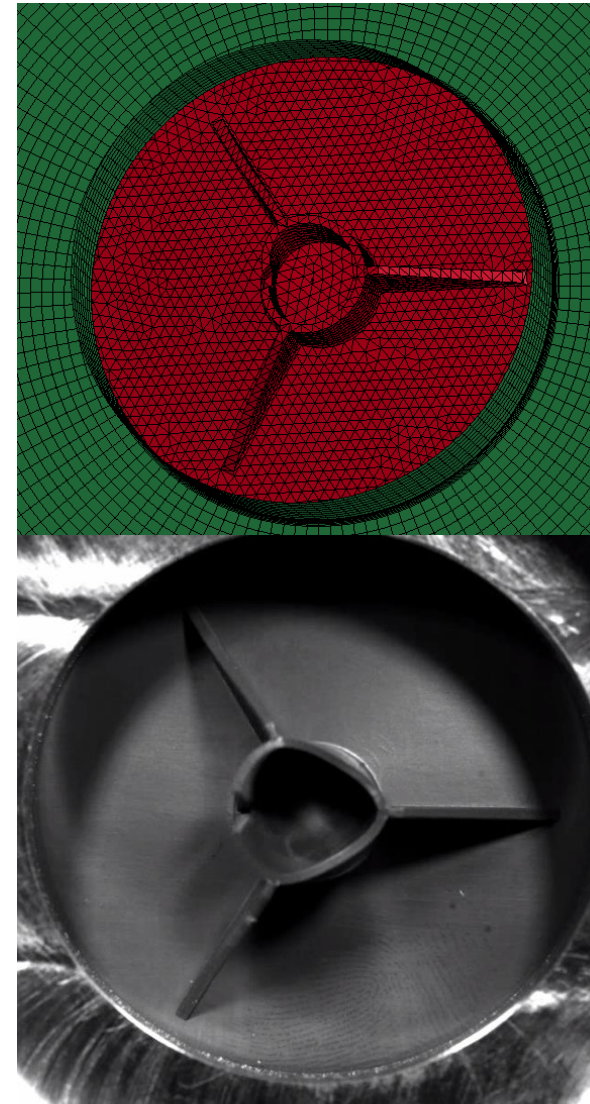
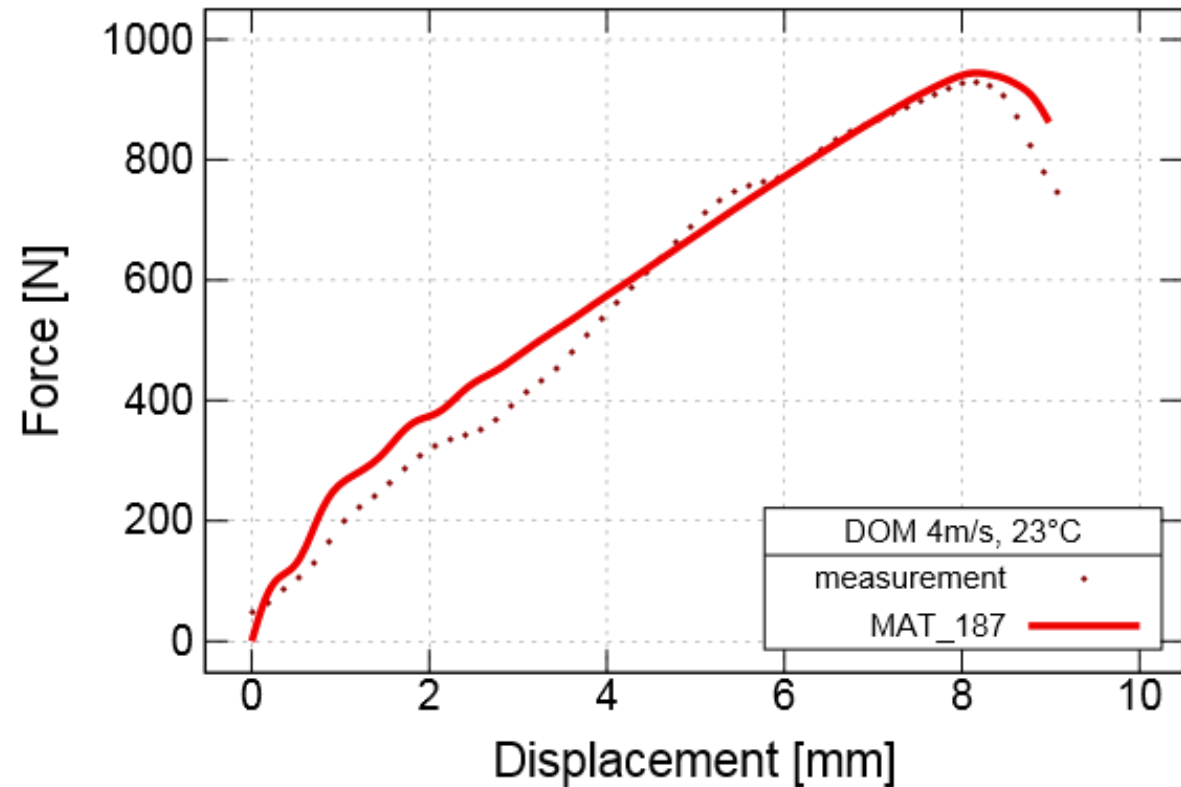
Multi-Specimen & Rib & Component



MPIP – from failure → *MAT_ADD_EROSION



from failure → Validation on component



from test to material card

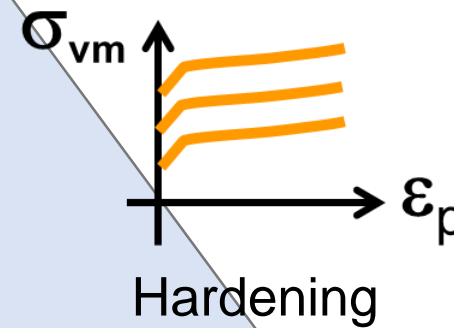
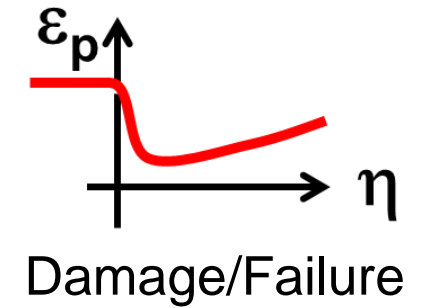
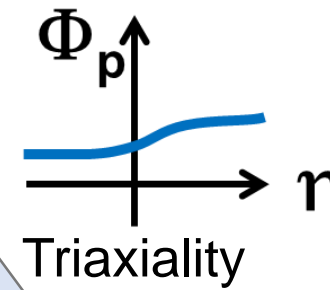
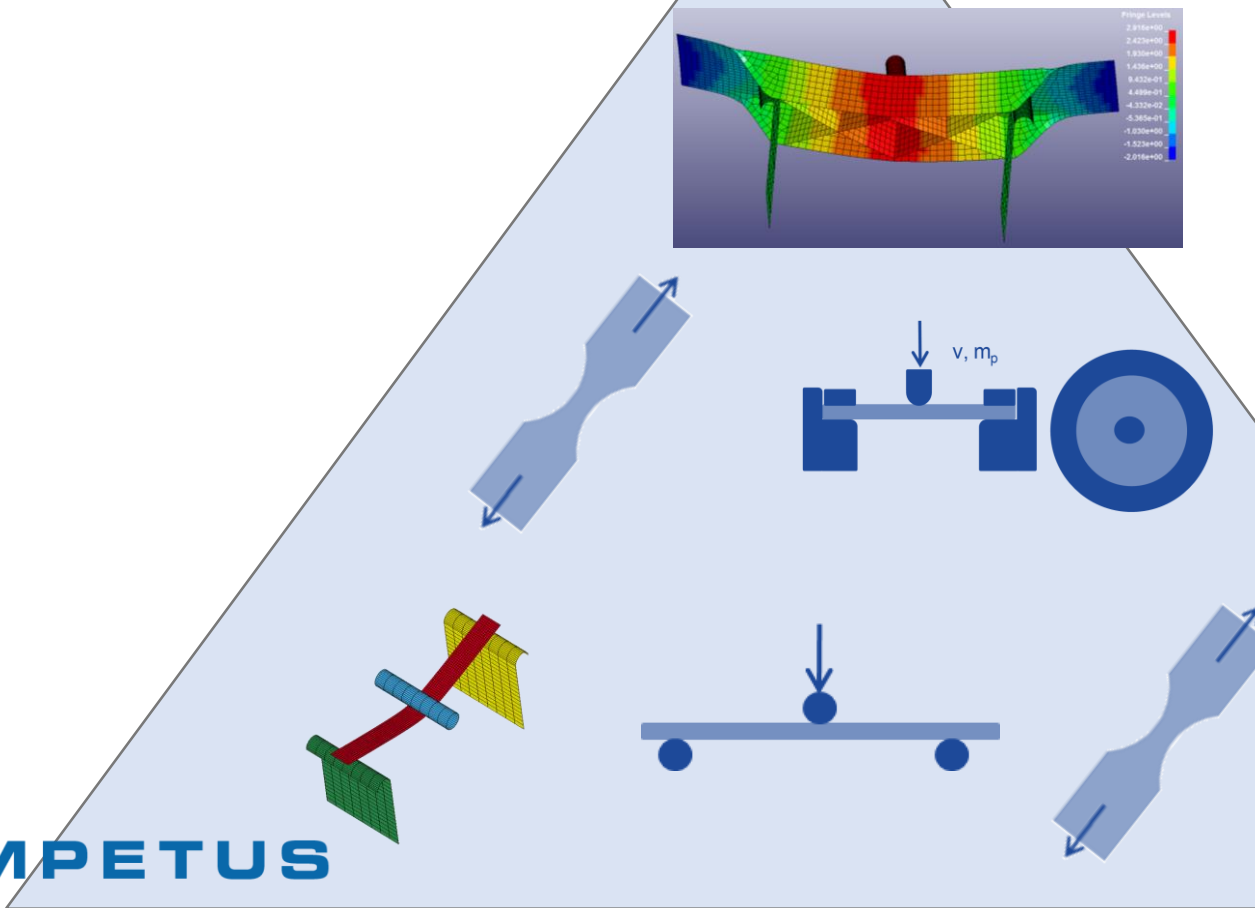
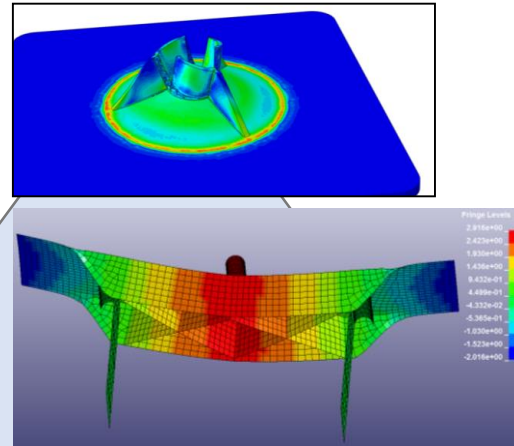


VALIMAT

Deformation → Failure

Creep → Static → Crash

ISOTROPIC → ANISOTROPIC

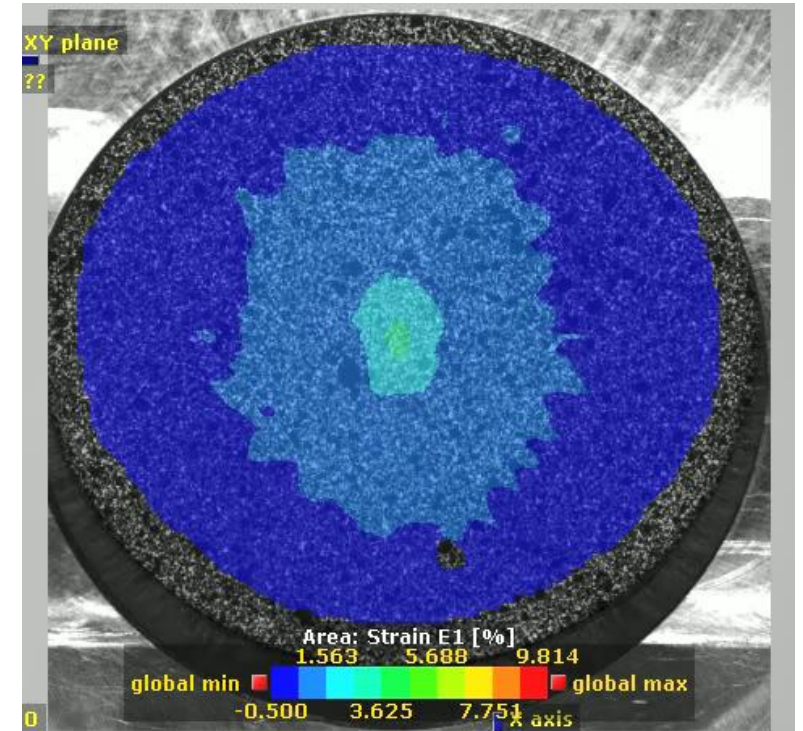


IMPETUS



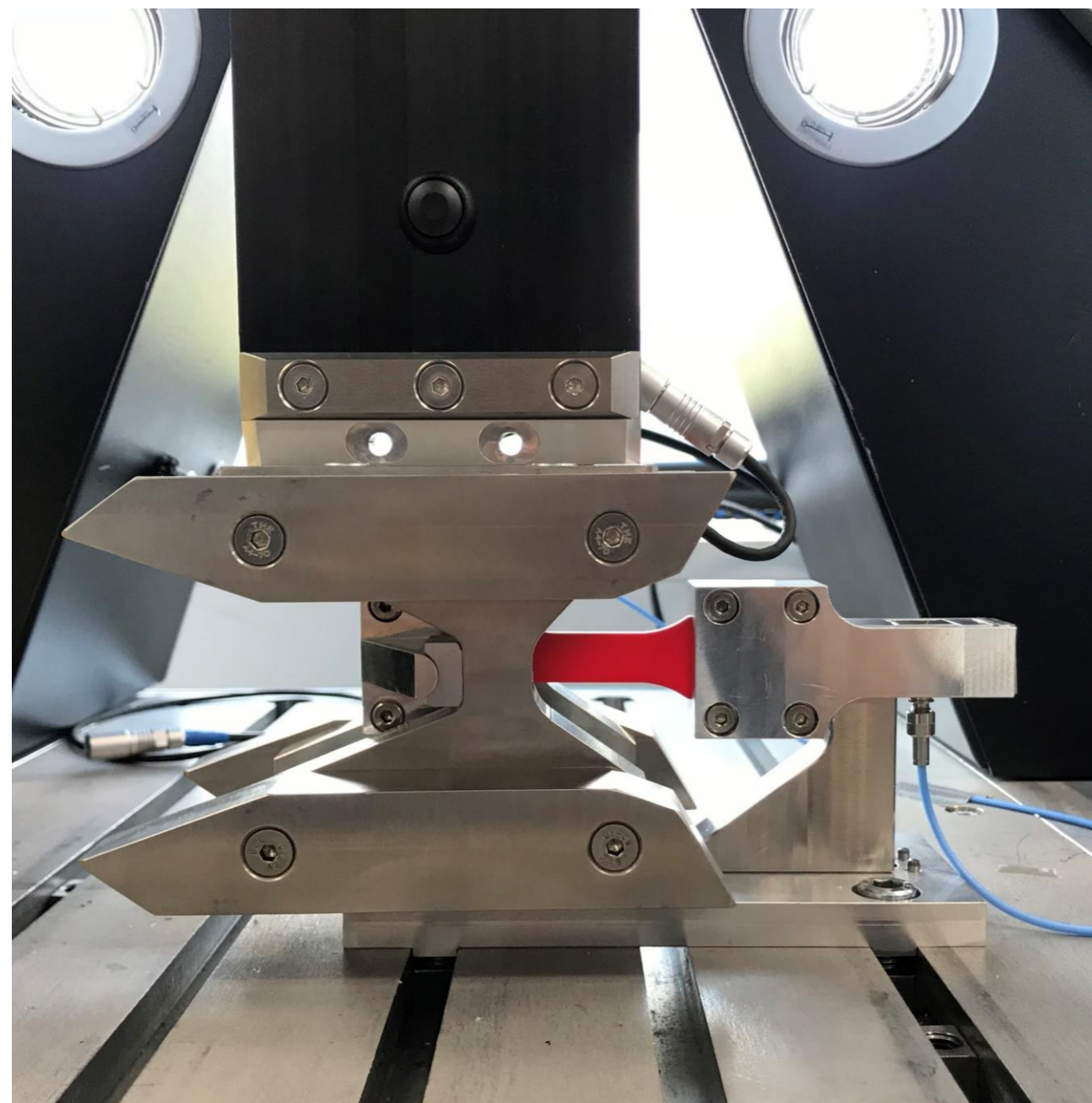
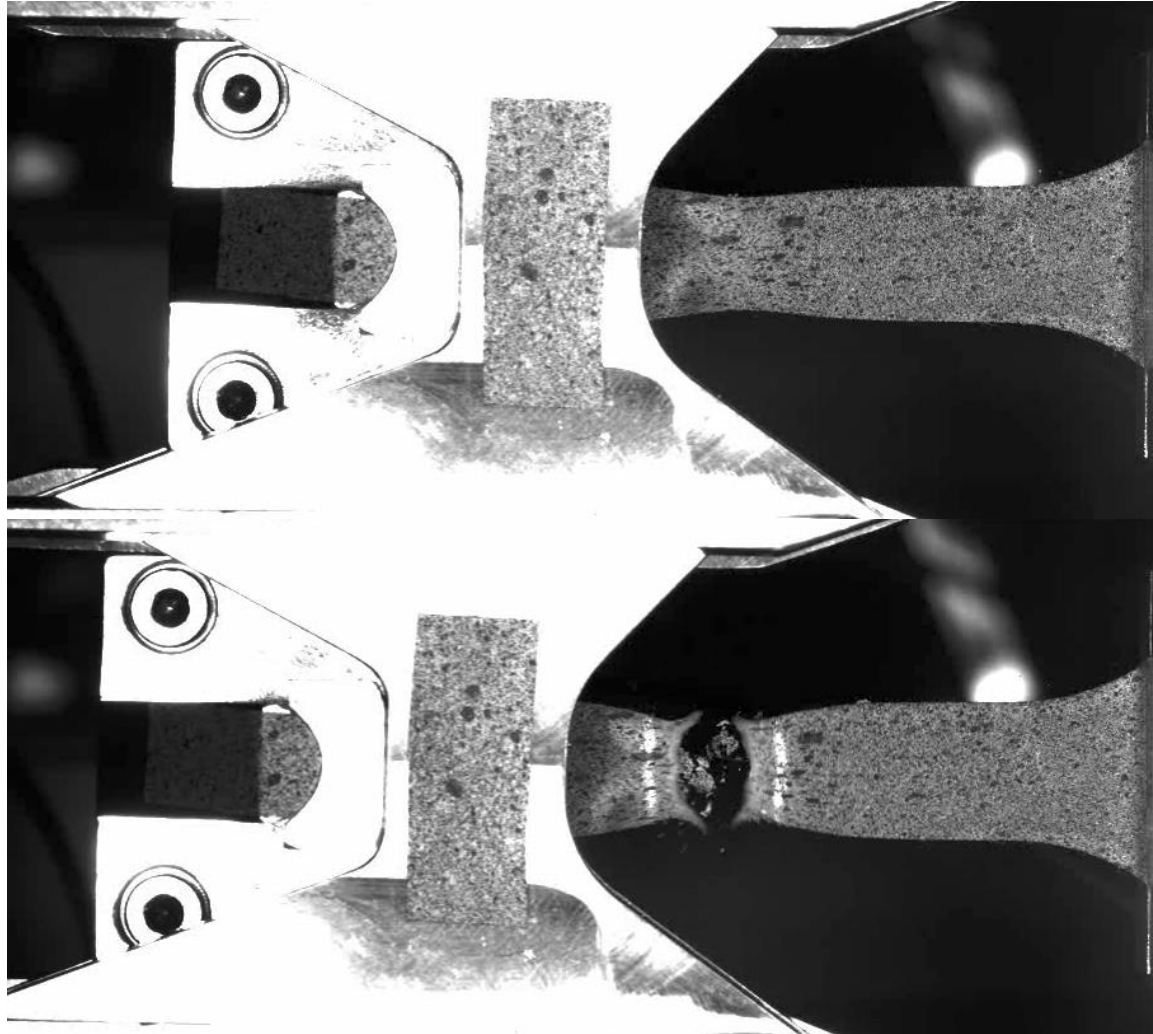
Summary & Outlook

- advantages micro mechanical approach
 - model understands → **fiber orientation, aspect ratio**
 - simulation process chain considering local anisotropy
process → structural
- Validation results (coupon and component level)
 - Good correlation in deformation behavior
 - promising results in capturing failure
→ **improvement post failure especially shells**
- Outlook
 - failure/damage → further research
 - DIC measurement – biaxial behavior
 - Usage for endless fiber reinforced materials



See more: Master Thesis, Christine Jantos - THM

Outlook - Dynamic tensile testing





Ideen
die Chance geben, sich zu
verwirklichen.
Thomas A. Edison